SOLVED PAPER

DPMT - 2005*

1. S.I. unit of magnetic flux is
(a) tesla (b) oersted
(c) weber (d) gauss.

2. A body of mass m is moving towards east and another body of equal mass is moving towards north. If after collision both stick together, their speed after collision would be
(a) v (b) $v/2$
(c) $\sqrt{2}\,v$ (d) $v/\sqrt{2}$

3. A body of mass 1 kg is moving in a vertical circular path of radius 1 m. The difference between the kinetic energies at its highest and lowest position is
(a) 20 J (b) 10 J
(c) $4\sqrt{5}$ J (d) $10(\sqrt{5}-1)$ J

4. Across each of two capacitors of capacitance 1 μF and 4 μF, a potential difference of 10 V is applied. Then positive plate of one is connected to the negative plate of the other, and negative plate of one is connected to the positive plate of the other. After contact,
(a) charge on each is zero
(b) charge on each is same but non-zero
(c) charge on each is different but non-zero
(d) none of these.

5. Magnification of a compound microscope is 30. Focal length of eye piece is 5 cm and the image is formed at a distance of distinct vision of 25 cm. The magnification of the objective lens is
(a) 6 (b) 5
(c) 7.5 (d) 10.

6. Kirchoff's law of junction, $\Sigma I = 0$, is based on
(a) conservation of energy
(b) conservation of charge
(c) conservation of energy as well as charge
(d) conservation of momentum.

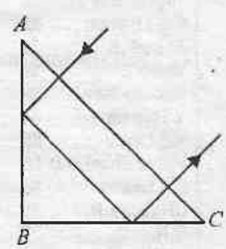
7. Calculate the amount of heat (in calories) required to convert 5 g of ice at 0°C to steam at 100°C .
(a) 3100 (b) 3200
(c) 3600 (d) 4200.

8. A transverse wave is expressed as : $y = y_0 \sin 2\pi ft$. For what value of λ, when maximum particle velocity is equal to 4 times the wave velocity?
(a) $y_0\pi/2$ (b) $2y_0\pi$
(c) $y_0\pi$ (d) $y_0\pi/4$.

9. Two bodies are thrown up at angles of 45° and 60°, respectively, with the horizontal. If both bodies attain same vertical height, then the ratio of velocities with which these are thrown is
(a) $\sqrt{2/3}$ (b) $2/\sqrt{3}$
(c) $\sqrt{3/2}$ (d) $\sqrt{3}/2$.

10. Charges $4Q$, q and Q are placed along x-axis at positions $x - 0$, $x = l/2$ and $x = l$, respectively. Find the value of q so that force on charge Q is zero.
(a) Q (b) $Q/2$
(c) $-Q/2$ (d) $-Q$.

11. A ray fall on a prism ABC ($AB - BC$) and traval as shown in figure. The least value of refractive index of material of the prism, should be



(a) 1.5
(b) $\sqrt{2}$
(c) 1.33
(d) $\sqrt{3}$

12. Escape velocity from a planet is v_e. If its mass is increased to 8 times and its radius is increased to 2 times, then the new escape velocity would be
(a) v_e (b) $\sqrt{2}v_e$
(c) $2v_e$ (d) $2\sqrt{2}v_e$

13. A body takes time t to reach the bottom of an inclined plane of angle θ with the horizontal. If the plane is made rough, time taken now is $2t$. The coefficient of friction of the rough surface is

* *based on memory*

(a) $\frac{3}{4}\tan\theta$ (b) $\frac{2}{3}\tan\theta$

(c) $\frac{1}{4}\tan\theta$ (d) $\frac{1}{2}\tan\theta$

14. Two small charged spheres A and B have charges 10 μC and 40 μC respectively, and are held at a separation of 90 cm from each other. At what distance from A, electric intensity would be zero?

(a) 22.5 cm (b) 18 cm

(c) 36 cm (d) 30 cm.

15. 50 tuning forks are arranged in increasing order of their frequencies such that each gives 4 beats/sec with its previous tuning fork. If the frequency of the last fork is octave of the first, then the frequency of the first tuning fork is

(a) 200 Hz (b) 204 Hz

(c) 196 Hz (d) none of these.

16. In a cyclotron, if a deuteron can gain an energy of 40 MeV, then a proton can gain an energy of

(a) 40 MeV (b) 80 MeV

(c) 20 MeV (d) 60 MeV.

17. Graph between velocity and displacement of a particle, executing SHM is

(a) a straight line (b) a parabola

(c) a hyperbola (d) an ellipse.

18. In the nuclear reaction,

$$^{180}_{72}X \xrightarrow{-\alpha} Y \xrightarrow{-\beta} Z \xrightarrow{-\alpha} A \xrightarrow{-\gamma} P$$

the atomic mass and number of P are, respectively

(a) 170, 69 (b) 172, 69

(c) 172, 70 (d) 170, 70.

19. A radioactive substance has activity 64 times higher than the required normal level. If $T_{1/2}$ = 2 hours, then the time, after which it should be possible to work with it, is

(a) 16 hrs. (b) 6 hrs.

(c) 10 hrs. (d) 12 hrs.

20. An electron, moving in a uniform magnetic field of induction of intensity $\vec{B}$, has its radius directly proportional to

(a) its charge (b) magnetic field

(c) speed (d) none of these.

21. The apparent frequency in Doppler's effect does not depend upon

(a) speed of the observer

(b) distance between observer and source

(c) speed of the source

(d) frequency from the source.

22. Two simple pendulums whose lengths are 100 cm and 121 cm are suspended side by side. Their bobs are pulled together and then released. After how many minimum oscillations of the longer pendulum, will the two be in phase again?

(a) 11 (b) 10

(c) 21 (d) 20.

23. If percentage change in current through a resistor is 1%, then the change in power through it would be

(a) 1% (b) 2%

(c) 1.7% (d) 0.5%

24. 3 identical bulbs are connected in series and these together dissipate a power P. If now the bulbs are connected in parallel, then the power dissipated will be

(a) $P/3$ (b) $3P$

(c) $9P$ (d) $P/9$.

25. Acceleration due to gravity

(a) decreases from equator to poles

(b) decreases from poles to equator

(c) is maximum at the centre of the earth

(d) is maximum at the equator.

SOLUTIONS

1. (c)

2. (d) : From the principle of conservation of linear momentum,

$$mv\hat{i} + mv\hat{j} = 2mv'$$

$$|2mv'| = m|v\hat{i} + v\hat{j}|$$

or, $$2mv' = m\sqrt{v^2 + v^2} \Rightarrow v' = \frac{\sqrt{2}v}{2} = \frac{v}{\sqrt{2}}.$$

3. (a) : Difference in kinetic energy

$$= \frac{1}{2}m[(\sqrt{5gr})^2 - (\sqrt{gr})^2]$$

$$= 2mgr = 2 \times 1 \times 10 \times 1 = 20 \text{ J}.$$

4. (c) : Stored charge on capacitor becomes zero only when it is discharged through resistance or when two capacitors of equal capacitance are charged and then connected to opposite terminals. Here the capacitances are different.

5. (c) : M.P. of compound microscope = $m_o \times m_e$

where $m_e = \frac{v}{u_e} = \frac{D}{u_e} = \left(1 + \frac{D}{f_e}\right) = \left(1 + \frac{25}{5}\right) = 6.$

$\therefore \quad 30 = m_o \times 6 \quad \Rightarrow \quad m_o = 5.$

6. (b) : Kirchoff's law of junction is based on the law of conservation of charges i.e. on the fact that charges do not remain accumulated at a junction of a circuit *i.e.* a junction of a circuit cannot act as source or sink of charges. Total rate of incoming charges is equal to the total rate of outgoing charges.

7. (c) : Heat required = heat require to melt ice to water of 0°C + heat require to boil water to 100°C + heat require to make steam at 100°C

$= mL_f + ms\Delta t + mL_s$

$= 5 \times 80 + 5 \times 1 \times 100 + 5 \times 540$

$= 400 + 500 + 2700 = 3600$ cal.

8. (a) : As given in question,
maximum particle velocity = 4 × wave velocity

$y_0\omega = \frac{4 \times \omega}{k} \Rightarrow y_0 = \frac{\lambda}{2\pi} \times 4$

$\therefore \quad \lambda = y_0\pi/2.$

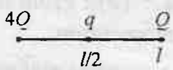
9. (c) : Vertical height $= \frac{u^2 \sin^2\theta}{2g}$

where u is initial velocity of the body.

$\therefore \quad \frac{u_1^2 \sin^2 45}{2g} = \frac{u_2^2 \sin^2 60}{2g}$

$\Rightarrow \quad \frac{u_1^2}{u_2^2} = \frac{\sin^2 60}{\sin^2 45} \Rightarrow \frac{u_1}{u_2} = \frac{\sqrt{3}/2}{1/\sqrt{2}} = \sqrt{\frac{3}{2}}.$

10. (d) : The total force on Q



$$\frac{Qq}{4\pi\varepsilon_0(l/2)^2} + \frac{4Q \times Q}{4\pi\varepsilon_0 l^2} = 0$$

$$\frac{Qq}{4\pi\varepsilon_0(l^2/4)} = -\frac{4Q \times Q}{4\pi\varepsilon_0 l^2} \Rightarrow q = -Q.$$

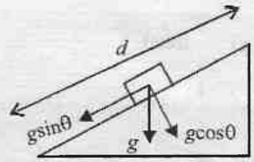
11. (b) : As $AB = BC$, $\angle A = \angle C = 45°$
At each reflection, $\angle i = 45° = i_c$, critical angle

$\therefore \quad \mu = \frac{1}{\sin i_c} = \frac{1}{\sin 45°} = \sqrt{2}.$

12. (c) : Escape velocity $= \sqrt{\frac{2GM}{R}} = v_e$

$v_e' = \sqrt{\frac{2G(8M)}{2R}} = 2\sqrt{\frac{2GM}{R}} = 2v_e.$

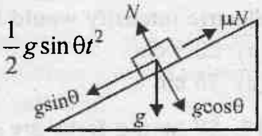
13. (a) : When body moves on frictionless surface then



$d = \frac{1}{2} g \sin\theta t^2$

When body moves on rough inclined

$d = \frac{1}{2} g(\sin\theta - \mu\cos\theta)(2t)^2$

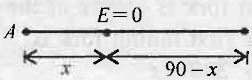


$\therefore \quad \frac{1}{2} g(\sin\theta - \mu\cos\theta)(2t)^2 = \frac{1}{2} g \sin\theta t^2$

$\Rightarrow \quad \sin\theta - \mu\cos\theta = \frac{\sin\theta}{4}$

$\Rightarrow \quad \mu\cos\theta = \sin\theta - \frac{\sin\theta}{4} = \frac{3}{4}\sin\theta \Rightarrow \mu = \frac{3}{4}\tan\theta.$

14. (d) : Let at a distance x the total electric intensity is zero.



$\therefore \quad \frac{q_A}{4\pi\varepsilon_0 x^2} + \frac{q_B}{4\pi\varepsilon_0(90 - x)^2} = 0$

$\Rightarrow \quad \frac{10}{x^2} \times 10^{-6} = \frac{40 \times 10^{-6}}{(90 - x)^2} \Rightarrow (90 - x^2) = 4x^2$

$\Rightarrow \quad 90 - x = 2x \Rightarrow 3x = 90 \Rightarrow x = 30$ cm.

15. (c) : As given, $\upsilon_2 = \upsilon + 4$
Similarly, $\upsilon_n = \upsilon + (n - 1) \times 4$
From given condition, $\upsilon_n = 2\upsilon$

$\Rightarrow \quad \upsilon + (50 - 1) \times 4 = 2\upsilon \Rightarrow \upsilon = 196$ Hz.

16. (b) : $R = \frac{\sqrt{2mE}}{qB} \Rightarrow \sqrt{2mE} = RqB$

As R is a constant for the cyclotron (it is cyclotron radius) and q for the deuteron and proton are the same, RqB is a constant.

$\therefore \quad \sqrt{2m_p \cdot E_p} = \sqrt{2m_d \cdot E_d}$

$\Rightarrow \sqrt{2m_p \cdot E_p} = \sqrt{2(2m_p)E_d}$

$\therefore \quad E_p = 2E_d = 2 \times 40 = 80$ MeV.

17. (d) : In simple harmonic motion,
$y = a \sin\omega t, \quad v = a\omega\cos\omega t$
From this, we have

$\frac{y^2}{a^2} + \frac{v^2}{a^2\omega^2} = 1$, which is equation of ellipse.

18. (b) : ${}^{180}_{72}X \xrightarrow{\alpha} {}^{176}_{70}Y + {}^4_2\text{He} \xrightarrow{\beta} {}^{176}_{71}Z + e^{0}_{-1}$

$\xrightarrow{\alpha} {}^{172}_{69}A + {}^4_2\text{He} \xrightarrow{\gamma} {}^{172}_{69}A$ + energy

19. (d) : $\left(\frac{A}{A_0}\right)=\left(\frac{1}{2}\right)^n \Rightarrow \left(\frac{1}{64}\right)=\left(\frac{1}{2}\right)^n$

$\Rightarrow \left(\frac{1}{2}\right)^6=\left(\frac{1}{2}\right)^n \Rightarrow n=6$

$nT_{1/2} = T \Rightarrow T = 6 \times 2 = 12$ hr.

20. (c) : When electron moves in a magnetic field,

$$\frac{mv^2}{r}=qvB \Rightarrow r=\frac{mv}{qB}.$$

21. (b) : Apparent frequency in Doppler effect depends on frequency of source, direction and velocity of source and observer.

22. (b) : $T=2\pi\sqrt{\frac{l}{g}}$

For l = 121 cm and l = 100 cm

$(n)11 = (n + 1)10. \quad \therefore \quad n = 10.$

23. (b) : Power = I^2R

$$\frac{\Delta P}{P}=2\frac{\Delta I}{I}+\frac{\Delta R}{R}. \quad \therefore \quad \Delta P = 2 \times 1\% + 0 = 2\%.$$

24. (c) : When bulbs are connected in series,

$$P=\frac{V^2}{R'}-\frac{V^2}{3R}$$

When bulbs are connected in parallel,

$$P'=\frac{V^2}{R''}=\frac{V^2\times 3}{R}=3\times 3P=9P.$$

25. (b) : At poles, the effect of rotation is negligible because of which g is maximum while at equator the effect of rotation on g is the maximum. Therefore, value of g is minimum. Thus as we go from pole to equator acceleration due to gravity decreases.

For complete solved paper of DPMT-2005, refer 'MTG's DPMT Explorer.

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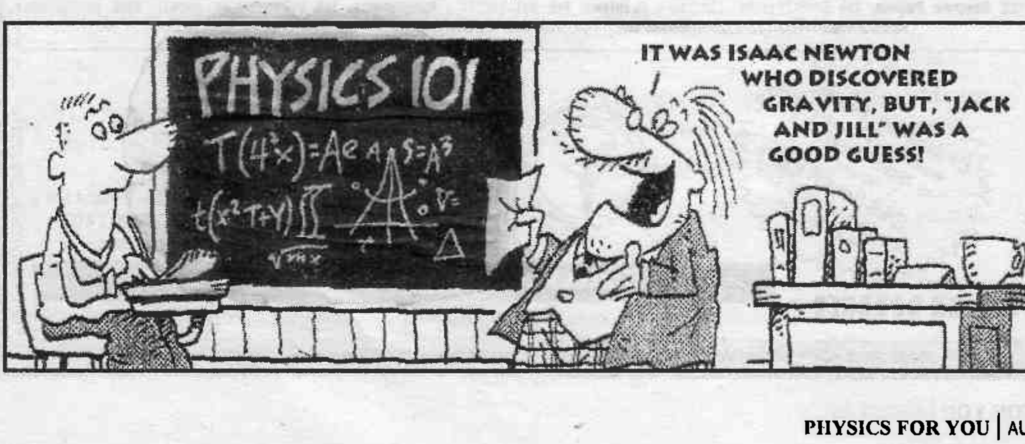


SOLVED PAPER

DCE - 2005*

1. An organ pipe, open from both end produces 5 beats per second when vibrated with a source of frequency 200 Hz. The second harmonic of the same pipes produces 10 beats per second with a source of frequency 420 Hz. The frequency of source is
(a) 195 Hz (b) 205 Hz (c) 190 Hz (d) 210 Hz.

2. Two rings of radius R and nR made up of same material have the ratio of moment of inertia about an axis passing through centre is 1 : 8. The value of n is
(a) 2 (b) $2\sqrt{2}$ (c) 4 (d) 1/2.

3. One drop of soap bubble of diameter D breaks into 27 drops having surface tension σ. The change in surface energy is
(a) $2\pi\sigma D^2$ (b) $4\pi\sigma D^2$
(c) $\pi\sigma D^2$ (d) $8\pi\sigma D^2$.

4. The gas having average speed four times as that of SO_2 (molecular mass 64) is
(a) He (molecular mass 4)
(b) O_2 (molecular mass 32)
(c) H_2 (molecular mass 2)
(d) CH_4 (molecular mass 16)

5. A container having 1 mole of a gas at a temperature 27°C has a movable piston which maintains at constant pressure in container of 1 atm. The gas is compressed until temperature becomes 127°C. The work done is (C_p for gas is 7.03 cal/mol-K)
(a) 703 J (b) 814 J (c) 121 J (d) 2035 J.

6. An electron having mass (9.1×10^{-31} kg) and charge (1.6×10^{-19} C) moves in a circular path of radius 0.5 m with a velocity 10^6 m/s in a magnetic field. Strength of magnetic field is
(a) 1.13×10^{-5} T (b) 5.6×10^{-6} T
(c) 2.8×10^{-6} T (d) none of these.

7. A cylinder rolls down an inclined plane of inclination 30°, the acceleration of cylinder is
(a) $g/3$ (b) g (c) $g/2$ (d) $2g/3$.

8. A period of a planet around Sun is 27 times that of Earth. The ratio of radius of planet's orbit to the radius of Earth's orbit is
(a) 4 (b) 9 (c) 64 (d) 27.

9. 3 particles each of mass m are kept at vertices of an equilateral triangle of side L. The gravitational field at centre due to these particles is
(a) zero (b) $\frac{3GM}{L^2}$
(c) $\frac{9GM}{L^2}$ (d) $\frac{12}{\sqrt{3}}\frac{GM}{L^2}$.

10. A solid sphere of radius R is rolling with velocity v on a smooth plane. The total kinetic energy of sphere is
(a) $\frac{7}{10}mv^2$ (b) $\frac{3}{4}mv^2$
(c) $\frac{1}{2}mv^2$ (d) $\frac{1}{4}mv^2$

11. A block is kept on an inclined plane of inclination θ of length l. The velocity of particle at the bottom of inclined is (the coefficient of friction is μ)
(a) $[2gl(\mu\cos\theta - \sin\theta)]^{1/2}$
(b) $\sqrt{2gl(\sin\theta - \mu\cos\theta)}$ (c) $\sqrt{2gl(\sin\theta + \mu\cos\theta)}$
(d) $\sqrt{2gl(\cos\theta + \mu\sin\theta)}$

12. If earth is supposed to be a sphere of radius R, if g_{30} is value of acceleration due to gravity at lattitude of 30° and g at the equator, the value of $g - g_{30°}$ is
(a) $\frac{1}{4}\omega^2 R$ (b) $\frac{3}{4}\omega^2 R$
(c) $\omega^2 R$ (d) $\frac{1}{2}\omega^2 R$

13. An organ pipe open at one end is vibrating in first overtone and is in resonance with another pipe open at both ends and vibrating in third harmonic. The ratio of length of two pipes is
(a) 1 : 2 (b) 4 : 1 (c) 8 : 3 (d) 3 : 8.

14. A coil takes 15 min to boil a certain amount of water, another coil takes 20 min for the same process.

* *based on memory*

Time taken to boil the same amount of water when both coil are connected in series,

(a) 5 min (b) 8.6 min
(c) 35 min (d) 30 min.

15. Two capillary of length L and $2L$ and of radius R and $2R$ are connected in series. The net rate of flow of fluid through them will be (given rate of the flow through single capillary, $X = \pi PR^4/8\eta L$)

(a) $\frac{8}{9}X$ (b) $\frac{9}{8}X$
(c) $\frac{5}{7}X$ (d) $\frac{7}{5}X$

16. A charge q is fixed. Another charge Q is brought near it and rotated in a circle of radius r around it. Work done during rotation is

(a) zero (b) $\frac{Q\cdot q}{4\pi\varepsilon_0 r}$
(c) $\frac{Q\cdot q}{2\varepsilon_0 r}$ (d) none of these.

17. Advantage of optical fibre

(a) high bandwidth and EM interference
(b) low band width and EM interference
(c) high band width, low transmission capacity and no EM interference
(d) high bandwidth, high data transmission capacity and no EM interference.

18. In an electromagnetic wave, direction of propagation is in the direction of

(a) $\vec{E}$ (b) $\vec{B}$
(c) $\vec{E}\times\vec{B}$ (d) none of these.

19. F_1 and F_2 are focal length of objective and eyepiece respectively of the telescope. The angular magnification for the given telescope is equal to

(a) $\frac{F_1}{F_2}$ (b) $\frac{F_2}{F_1}$
(c) $\frac{F_1F_2}{F_1+F_2}$ (d) $\frac{F_1+F_2}{F_1F_2}$

20. Critical velocity of the liquid

(a) decreases when radius decreases
(b) increases when radius increases
(c) decreases when density increases
(d) increases when density increases.

21. A diode having potential difference 0.5 V across its junction which does not depend on current, is connected in series with resistance of 20 Ω across source. If 0.1 A passes through resistance then what is the voltage of the source?

(a) 1.5 V (b) 2.0 V (c) 2.5 V (d) 5 V.

22. Potentiometer wire of length 1 m is connected in series with 490 Ω resistance and 2 V battery. If 0.2 mV/cm is the potential gradient, then resistance of the potentiometer wire is

(a) 4.9 Ω (b) 7.9 Ω (c) 5.9 Ω (d) 6.9 Ω.

23. Dipole is placed parallel to the electric field. If W is the work done in rotating the dipole by 60°, then work done in rotating it by 180° is

(a) $2W$ (b) $3W$ (c) $4W$ (d) $W/2$.

24. An electron of charge e moves in a circular orbit of radius r around the nucleus at a frequency υ. The magnetic moment associated with the orbital motion of the electron is

(a) $\pi\upsilon er^2$ (b) $\frac{\pi\upsilon r^2}{e}$
(c) $\frac{\pi\upsilon e}{r}$ (d) $\frac{\pi er^2}{\upsilon}$.

25. A and B are two identically spherical charged body which repel each other with force F, kept at a finite distance. A third uncharged sphere of the same size is brought in contact with sphere B and remived. It is then kept at mid-point of A and B. Find the magnitude of force on C.

(a) $F/2$ (b) $F/8$ (c) F (d) zero.

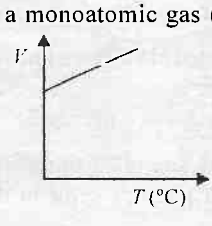
26. A composite rod is made of copper ($\alpha = 1.8\times10^{-5}\ K^{-1}$) and steel ($\alpha - 1.2\times10^{-5}\ K^{-1}$) is heated then it

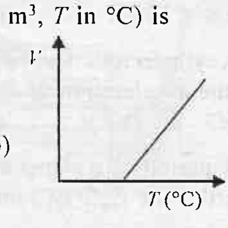
(a) bends with steel on concave side
(b) bends with copper on concave side
(c) does not expand (d) data is insufficient.

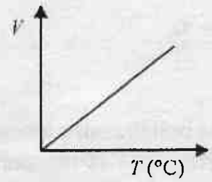
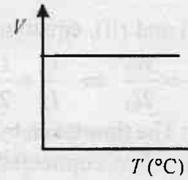
27. A wave of equation $y = 0.1\sin[100\pi t - kx]$ and wave velocity 100 m/s, its wave number is equal to

(a) 1 m^{-1} (b) 2 m^{-1} (c) π m^{-1} (d) 2π m^{-1}.

28. Volume-temperature graph at atmospheric pressure for a monoatomic gas (V in m^3, T in °C) is

(a) 

(b) 

(c)  (d) 

29. In X-ray experiment K_α, K_β denotes
(a) characteristic lines
(b) continuous wavelength
(c) α, β-emissions respectively
(d) none of these.

30. The ratio of frequencies of two pendulums are 2 : 3, then their length are in ratio
(a) $\sqrt{2/3}$ (b) $\sqrt{3/2}$ (c) 4/9 (d) 9/4

31. The value of escape velocity on a certain planet is 2 km/s. Then the value of orbital speed for a satellite orbiting close to its surface is
(a) 12 km/s (b) 1 km/s
(c) $\sqrt{2}$ km/s (d) $2\sqrt{2}$ km/s.

32. The electrochemical equivalent of a metal is 3.3×10^{-7} kg/C. The mass of metal liberated at cathode by 3 A current in 2 sec will be
(a) 19.8×10^{-7} kg (b) 9.9×10^{-7} kg
(c) 6.6×10^{-7} kg (d) 1.1×10^{-7} kg.

33. For a paramagnetic material, the dependence of the magnetic susceptibility χ on the absolute temperature is given as
(a) $\chi \propto T$ (b) $\chi \propto 1/T^2$
(c) $\chi \propto 1/T$ (d) independent.

34. An optically active compound
(a) rotates the plane polarised light
(b) changing the direction of polarised light
(c) do not allow plane polarised light to pass through
(d) none of the above.

35. Three particles A, B and C are thrown from the top of a tower with the same speed. A is thrown up, B is thrown down and C is horizontally. They hit the ground with speeds V_A, V_B and V_C respectively.
(a) $V_A = V_B = V_C$ (b) $V_A = V_B > V_C$
(c) $V_B > V_C > V_A$ (d) $V_A > V_B = V_C$.

SOLUTIONS

1. **(b)** : In first case, $f \sim 200 = 5$
$\therefore$ $f = 195$ Hz or, 205 Hz.

In second case, $2f \sim 420 = 10$
$\therefore$ $f = 205$ Hz or, 215 Hz.
$\therefore$ The value of $f = 205$ Hz satisfies both the conditions.

2. **(a)** : The moment of inertia of circular ring whose axis of rotation is passing through its centre, $I_1 = mR^2$.
Also, $I_2 = m_2(nR)^2$
Since both ring have same density,

$$\therefore \quad \frac{m_2}{2\pi(nR)\times A} = \frac{m}{2\pi R\times A}$$

where A is cross-section area of ring.
$\therefore$ $m_2 = nm$.

$$\text{Also, } \frac{I_1}{I_2} = \frac{1}{8} = \frac{mR^2}{m_2(nR)^2} = \frac{mR^2}{nm(nR)^2}$$

$$\Rightarrow \quad \frac{1}{8} = \frac{1}{n^3} \Rightarrow n = 2.$$

3. **(d)** : Change in surface energy, (ΔW)
= surface tension × change in surface area of bubble
$= \sigma\ [27 \times 4\pi d^2 - 4\pi D^2]$
Volume of bigger bubble = volume of 27 smaller bubbles

$$\Rightarrow \quad \frac{4}{3}\pi D^3 = 27\times\frac{4}{3}\pi d^3 \Rightarrow d = \frac{D}{3}.$$

$$\therefore \quad \Delta W = \sigma\times 4\pi\left[27\times\frac{D^2}{9} - D^2\right]$$

$$= 2D^2 \times 4\pi \times \sigma = 8\pi\sigma D^2.$$

4. **(a)** : Velocity $\propto \dfrac{1}{\sqrt{\text{molecular mass}}}$

$$\therefore \quad \frac{v_1}{v_2} = \sqrt{\frac{M_2}{M_1}} \Rightarrow 4 = \sqrt{\frac{64}{M_1}} \Rightarrow M_1 = 4 \text{ i.e. He.}$$

5. **(b)** : $W = P(V_f - V_i) = nR(T_f - T_i)$
$= 1 \times 8.14\ (127 - 27) = 8.14 \times 100 = 814$ J.

6. **(a)** : $\dfrac{mv^2}{r} = qvB$

$$B = \frac{mv}{qr} = \frac{9.1\times10^{-31}\times10^6}{1.6\times10^{-19}\times0.5} = 11.37\times10^{-6}\ \text{T}$$

$$= 1.13 \times 10^{-5}\ \text{T}.$$

7. **(a)** : Acceleration of a cylinder down a smooth inclined plane is

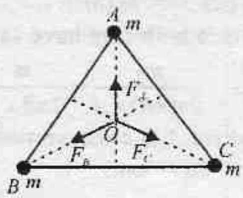
$$a = \frac{g\sin\theta}{(1 + I/mR^2)} \quad \text{where } I = \frac{mR^2}{2} \text{ for cylinder.}$$

$$a = \frac{g\sin 30^\circ}{\left(1 + \frac{mR^2}{2}\times\frac{1}{mR^2}\right)} = \frac{g\times 1/2}{1 + 1/2} = \frac{g}{3}$$

8. (b) : According to Kepler's third law,
$R^3 \propto T^2$

$$\therefore \quad \frac{R}{R_e} = \left(\frac{T}{T_e}\right)^{2/3} = \left(\frac{27T_e}{T_e}\right)^{2/3} = 9.$$

9. (a) : The gravitational field intensity at point O is the net force exerted on a unit mass placed at O due to three equal masses m at vertices A, B and C. Since the three masses are equal and their distance from O are also equal, they exert force F_A, F_B and F_C of equal magnitude. It follows from symmetry of forces that their resultant at point O is zero.



10. (a) : Kinetic energy = translational kinetic energy + rotational kinetic energy

$$= \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

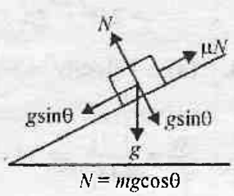
Moment of inertia of sphere $(I) = \frac{2}{5}MR^2$

$$\therefore \quad K.E. = \frac{1}{2}mv^2 + \frac{1}{2}\times\frac{2}{5}MR^2\left(\frac{v}{R}\right)^2 = \frac{7}{10}mv^2.$$

11. (b) : Acceleration of block

$$= g\sin\theta - \mu_k\frac{N}{m}$$
$$= g\sin\theta - g\mu_k\cos\theta$$
$$= g(\sin\theta - \mu_k\cos\theta)$$

From straight line equation,
$v^2 - u^2 = 2as$



i.e. $v^2 = 2\times g(\sin\theta - \mu\cos\theta)l$

or, $v = \sqrt{2gl(\sin\theta - \mu\cos\theta)}$.

12. (b) : Acceleration due to gravity at lattitude λ is given by
$g' = g - R\omega^2\cos^2\lambda$

At 30°, $g_{30} = g - R\omega^2\cos^2 30° = g - \frac{3}{4}R\omega^2$

or, $g - g_{30} = \frac{3}{4}\omega^2 R$.

13. (a) : In first overtone of organ pipe open at one end, $\quad \upsilon_c = \frac{3v}{4l_c}$ ... (i)

Third harmonic or second overtone of organ pipe open at both end, $\quad \upsilon_o = \frac{3v}{2l_o}$ ... (ii)

From (i) and (ii), equation, $\quad \upsilon_c = \upsilon_o$

$$\Rightarrow \quad \frac{3v}{4l_c} = \frac{3v_0}{2l_0} \Rightarrow \frac{l_c}{l_o} = \frac{1}{2}.$$

14. (c) : The time taken by coils to boil the same amount of water when connected in series, as V is the same, the current decreases,
time $t = t_1 + t_2 = 35$ min.

15. (a) : Fluid resistance is given by $R = \frac{8\eta l}{\pi r^4}$.

When two capillary tubes of same size are joined in parallel, then equivalent fluid resistance is

$$R_s = R_1 + R_2 = \frac{8\eta L}{\pi r^4} + \frac{8\eta\times 2L}{\pi(2R)^4} = \left(\frac{8\eta L}{\pi r^4}\right)\times\frac{9}{8}$$

Rate of flow $= \frac{P}{R_s} = \frac{\pi Pr^4}{8\eta L}\times\frac{8}{9} = \frac{8}{9}X.$ $\left[\text{as } X = \frac{\pi PR^4}{8\eta l}\right]$

16. (a) : The charge is moving in an equipotential line. So no work is done.

17. (d) : Few advantages of optical fibres are that the number of signals carried by optical fibers is much more than that carried by the copper wire or radio waves. Optical fibers are practically free from electromagnetic interference and problem of cross talks whereas ordinary cables and microwaves links suffer a lot from it.

18. (c)

19. (a) : The angular magnification produced by an optical instrument is defined as

$$M = \frac{\text{angle subtended at eye using instrument}}{\text{angle subtended at unaided eye}}$$

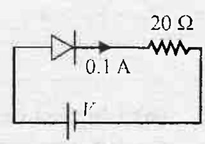
For telescope, $\quad M = \frac{f_o}{f_e} = \frac{F_1}{F_2}$.

20. (c) : Critical velocity of a liquid,

$$v_c = \frac{k\eta}{\rho r}$$

where η is coefficient of viscosity of the liquid, ρ its density and r is the radius of the tube. k is a dimensionless constant called the Reynold number. Thus critical velocity increases when density and radius of the tube decreases.

21. (c) : $V' = V + IR$
$= 0.5 + 0.1 \times 20$
$= 2.5$ V.



22. (a) : Potential across potentiometer wire

$= \frac{(0.2\times10^{-3})\text{ V}\times 1\text{ m}}{10^{-2}\text{ m}} = 0.02\text{ V}$

Also $0.02 = \frac{R}{r+R}\times 2$

where R is resistance of potentiometer wire and r is resistance connected in series.

$\therefore\quad 0.02(490 + R) = 2R \quad\Rightarrow\quad 9.8 + 0.02R = 2R$

$\Rightarrow\quad 9.8 = 2R - 0.02R \quad\Rightarrow\quad R = \frac{9.8}{1.98} = 4.9\ \Omega.$

23. (a) : Work done = $-pE\cos\theta$

$W = -pE\cos 60°$

$W = \frac{-pE}{2} \Rightarrow |W| = \left|\frac{pE}{2}\right|$

where p is dipole moment of dipole and E is the electric field applied.

The work done required to rotate dipole by 180° is

$W' = -pE\cos 180° = pE = 2W.$

24. (a) : The charge passing per second through any point of the path is ν times the charge of the electron.

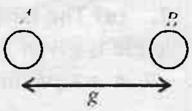
i.e. $I = \nu e$

If A is the area of the orbit, the magnetic moment is

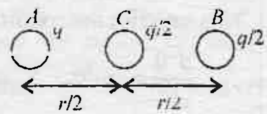
$m = IA = \nu e\pi r^2.$

25. (c) : Let initially both the sphere having charge q. Thus force between A and B sphere kept at a distance r is given as

$F = \frac{qq}{4\pi\varepsilon_0 r^2}$



When two identical metallic spheres are brought in contact, the charge on them are equalised due to the flow of free electrons. Thus when an uncharged sphere C is brought in contact with sphere B having a charge q and then removed, the total charge q is equally shared between two so that the charge left on B is $q/2$ and that developed on C is $q/2$.



The force on C when it is placed between A and B is given as

$F_C = \frac{q\times(q/2)}{4\pi\varepsilon_0(r/2)^2} - \frac{(q/2)\times(q/2)}{4\pi\varepsilon_0(r/2)^2} = \frac{qq}{4\pi\varepsilon_0}[2-1] = F.$

26. (b) : As coefficient of linear expansion of copper is more than steel therefore it expand more than steel with same amount of change in temperature.

27. (c) : Wave equation

$y = 0.1\sin(100\pi t - kx)$

Comparing with general equation,

$y = 0.1\sin(\omega t - kx) \Rightarrow k = \frac{\omega}{v} = \frac{100\pi}{100} = \pi\text{ m}^{-1}.$

28. (c) : $V \propto T$

29. (a) : As we know $n = 1$ shell is known as the K-shell. In X-ray experiment when X-rays are emitted in the process of filling the vacancy at K shell they are known as K shell X-rays. The K-X ray that originates with the $n = 2$ shell is known as K_α X-ray and the KX-rays originating from higher shells are known as K_β, K_γ and so forth.

30. (d) : Frequency of pendulum $\propto \frac{1}{\sqrt{\text{length}}}$

$\frac{f_1}{f_2} = \sqrt{\frac{l_2}{l_1}} \Rightarrow \frac{l_1}{l_2} = \frac{f_2^2}{f_1^2} = \frac{3^2}{2^2} = \frac{9}{4}.$

31. (c) : Escape velocity = $\sqrt{2gR} = v_e$

Orbital velocity = $\sqrt{gR} = v_e/\sqrt{2}$

$v_0 = \frac{2}{\sqrt{2}} = \sqrt{2}$ km/s.

32. (a) : From Faraday's first law of electrolysis mass of a substance liberated = ZIt

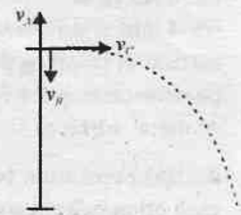
$= 3.3\times10^{-7}\times 3\times 2 = 19.8\times10^{-7}$ kg.

33. (c) : Paramagnetic material obey's Curie's law. According to which $\chi = C/T$.

where C is called Curie's constant.

34. (a) : When the plane-polarised light passes through certain substance, the plane of polarisation of the light is rotated about the direction of propagation of light through a certain angle.

35. (a) : When A is thrown up, it reaches to maximum height at zero velocity, comes back to A with the same initial velocity v_A. v_B has the same initial velocity. The vertical velocity $v_C = 0$. v_C is acting horizontal.



Whereas for A and $\sqrt{v_A^2 + 2gh}$ for A.

For B, $\sqrt{v_B^2 + 2gh}$

For C also, $\sqrt{v_C^2 + 2gh}$ *i.e.* $\sqrt{v_x^2 + v_y^2}$

$\therefore$ The final velocities are the same.

$\therefore$ v_f for $A = v_f$ for $B = v_f$ for C.

For complete solved paper, refer MTG's DCE Guide

SOLVED PAPER

CBSE PMT - 2005

Contd. from July 2005 issue

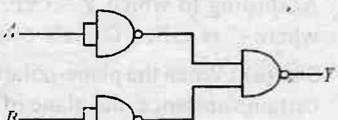
1. A lens of focal length of 20 cm and of refractive index 1.5 is placed inside a shell containing liquid of refractive index 1.6. What will be the focal length inside the liquid.

2. **(a)** Electric field and a dipole are in same direction. When the dipole is deflected in small angle does it exhibit SHM?

(b) Electric field inside a sphere varies with distance as Ar. Find the total charge enclosed within the sphere if $A = 3000$ V/m^2; $R = 30$ cm, where R is the radius of the sphere.

3. **(a)** If the radius of a coil is changing at the rate 10^{-2} units in a normal magnetic field 10^{-3} units, the induced emf is 1 μV. Find the final radius of the coil.

(b) Name the type of gate used in the circuit given, find the relation between A, B and Y and draw the truth table.



(c) Light of wavelength $\lambda = 4000$ Å incident on a metal surface. If stopping potential needed to stop the elected photoelectron is 1.4 volt, then find out the work function of metal surface.

4. **(a)** Separation between two parallel plates facing each other is 2 cm and surface area $l^2 = 100$ cm^2. If 10^6 electrons of velocity 10^8 m/sec projected into the gap between plates of potential difference $\phi = 400$ volt, find the deflection of an electron.

(b) Of an resonance circuit at which angular frequency, potential difference leads the current?

5. **(a)** Describe a β^- decay of a neutron.

(b) For a radioactive material half life period is 600 sec. If initially there are 600 number of molecules find the time taken for disintegration of 450 molecules and the rate of disintegration.

SOLUTIONS

1. The focal length of lens in air

$$\frac{1}{f_a} = (\mu_g - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad \text{... (i)}$$

The focal length of lens when placed in a liquid of refractive index 1.6

$$\frac{1}{f_l} = \left(\frac{\mu_g - \mu_l}{\mu_l}\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad \text{... (ii)}$$

From equation (i) and (ii),

$$\frac{f_l}{f_a} = \frac{\mu_l(\mu_g - 1)}{(\mu_g - \mu_l)} = \frac{(1.5-1)1.6}{(1.5-1.6)} = \frac{0.5 \times 1.6}{-0.1}$$

$\therefore$ $f_l = -8.0 \times f_a = -160$ cm.

The convex lens becomes a concave lens.

2. **(a)** The torque applied to deflect dipole by small angle is given by

$$\tau = -pE\sin\theta = -pE\theta$$

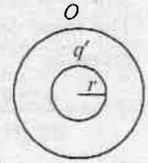
Also, $I\alpha = I\dfrac{d^2\theta}{dt^2} = -pE\theta$

This satisfies the condition of simple harmonic motion.

$$\frac{d^2\theta}{dt^2} = -\omega^2\theta. \quad \therefore \ \omega^2 = \frac{pE}{I}.$$

Thus time period $= 2\pi\sqrt{\dfrac{I}{pE}}$.

(b) By Gauss theorem, E at r inside the uniformly charged sphere



$$= \frac{q'}{\varepsilon_0} \cdot \frac{1}{4\pi r^2}$$

$$= \frac{Q}{\varepsilon_0 \cdot \frac{4}{3}\pi R^3} \cdot \frac{(4/3)\pi r^3}{4\pi r^2} = \left(\frac{Q}{4\pi\varepsilon_0 R^3}\right) r$$

$\therefore$ $E = Ar$.

Given $r_{max} = R = 0.30$ m

or, radius of the sphere is 30 cm.

$$q = Ar^3 \times 4\pi\varepsilon_0 = 3000\times(0.3)^3\times\frac{1}{9\times10^9}$$
$$= 3\times10^3\times(3)^3\times10^{-3}\times\frac{1}{9\times10^9}$$
$$= 9\times10^{-9}\ \text{C.}$$

3. **(a)** Area of coil $= \pi r^2$

$$\frac{dA}{dt} = 2\pi r\frac{dr}{dt}$$

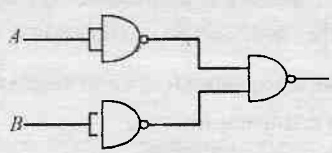
Induced emf $|e| = \left|\frac{d\phi}{dt}\right|$

$$|e| = B\frac{dA}{dt}\quad [\because \phi = BA]$$

$$1\times10^{-6} = 10^{-3}\times2\pi\times r\times10^{-2}$$

$$\Rightarrow\quad r = \frac{0.1}{2\pi} = 0.016\ \text{m} = 1.6\ \text{cm.}$$

(b) NAND gate is used in the circuit



A	B	$\overline{A}$	$\overline{B}$	$\overline{A}\cdot\overline{B}$	$Y = \overline{\overline{A}\cdot\overline{B}} = A+B$
0	0	1	1	1	0
0	1	1	0	0	1
1	0	0	1	0	1
1	1	0	0	0	1

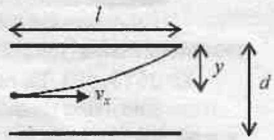
This work as OR gate as output of given circuit is equivalent to that only.

(c) Maximum kinetic energy of electron

$$= \text{stopping potential} = \frac{hc}{\lambda} - \text{work function}$$

$$\text{Work function} = \frac{6.6\times10^{-34}\times3\times10^8}{4000\times10^{-10}} - 1.4\ \text{eV}$$
$$= 4.95\times10^{-19} - 1.4\ \text{eV}$$
$$= 3.09 - 1.4 = 1.69\ \text{eV.}$$

4. **(a)** $y = \frac{1}{2}at^2$



$$= \frac{1}{2}\frac{qE}{m}\left(\frac{l}{v_x}\right)^2 = \frac{1}{2}\frac{qV}{dm}\left(\frac{l}{v_x}\right)^2$$

$$= \frac{1}{2}\times\frac{1.6\times10^{-19}\times400\times10^{-2}}{2\times10^{-2}\times9.1\times10^{-31}\times(10^8)^2}$$

$$= \frac{1.6}{9.1}\times10^{-2}\ \text{m} = 0.176\ \text{cm} = 1.76\ \text{mm.}$$

(b) If voltage leads the current in the resonant circuit,

$$\omega L - \frac{1}{\omega C} > 0$$

$$\Rightarrow\quad \omega L > \frac{1}{\omega C}\ \Rightarrow\ \omega^2 > \frac{1}{LC}\ \Rightarrow\ \omega > \frac{1}{\sqrt{LC}}.$$

5. **(a)** Neutron decays to a proton, an electron and an antineutrino. This is called neutron beta decay.

$$n \rightarrow p + e^- + \upsilon$$

(b) The original number of molecules $N_0 = 600$

If 450 molecules disintegration have taken place, the number of molecules remaining is $600 - 450 = 150$.

$$\frac{N}{N_0} = \left(\frac{1}{2}\right)^n\ \Rightarrow\ \frac{150}{600} = \left(\frac{1}{2}\right)^n$$

$$\Rightarrow\quad \frac{1}{4} = \left(\frac{1}{2}\right)^n\ \Rightarrow\ n = 2 = \frac{t}{T_{1/2}}$$

$\therefore\quad t = 2\times600 = 1200$ sec.

The rate of disintegration,

$$R = \frac{dN}{dt} = -\lambda N = \frac{0.693}{T_{1/2}}\times150$$

$$= \frac{0.693}{600}\times150 = 0.173\ \text{disintegrations/sec}$$

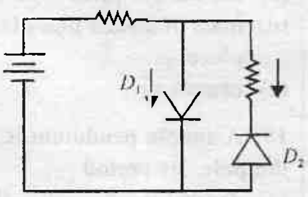
at that instant when 150 molecules were remaining.

SOLVED PAPER

KERALA PMT - 2005

1. One milligram of water is converted into energy, the energy released will be
(a) 90 J (b) 9×10^3 J
(c) 9×10^5 J (d) 9×10^{10} J
(e) 9×10^6 J.

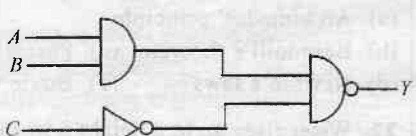
2. In the diode circuit given,



(a) D_1 and D_2 are reverse biased
(b) D_1 and D_2 are forward bias
(c) D_1 is forward biased and D_2 is reverse biased
(d) D_1 is reverse biased and D_2 is forward biased
(e) D_1 and D_2 will not conductive.

3. In *n-p-n* transistor, the collector current is 10 mA. If 90% of the electrons emitted reach the collector, then
(a) emitter current will be 9 mA
(b) emitter current will be 11.1 mA
(c) base current will be 0.1 mA
(d) base current will be 0.01 mA
(e) emitter current will be 11.3 mA.

4. In the given circuit the output Y becomes zero for the inputs



(a) $A = 1, B = 0, C = 0$ (b) $A = 0, B = 1, C = 1$
(c) $A = 0, B = 0, C = 0$ (d) $A = 1, B = 1, C = 1$
(e) $A = 1, B = 1, C = 0$.

5. In frequency modulation
(a) the amplitude of modulated wave varies as frequency of carrier wave
(b) the frequency of modulated wave varies as amplitude of modulating wave
(c) the amplitude of modulated wave varies as amplitude of carrier wave
(d) the frequency of modulated wave varies as frequency of modulating wave
(e) the frequency of modulated wave varies as frequency of carrier wave.

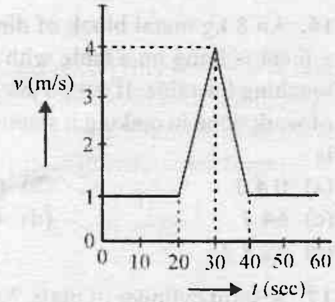
6. Audio signal cannot be transmitted because
(a) the signal has more noise
(b) the signal cannot be amplified for distance communication
(c) the transmitting antenna length is very small to design
(d) the transmitting antenna length is very large and impracticable
(e) the signal is not a radio signal.

7. In which of the following remote sensing technique is not used?
(a) forest density (b) pollution
(c) wetland mapping (d) ground water survey
(e) medical treatment.

8. If the unit of force and length are doubled, the unit of energy will be
(a) 1/4 times the original
(b) 1/2 times the original (c) 2 times the original
(d) 4 times the original (e) 8 times the original.

9. A car travels half the distance with constant velocity of 40 kmph and the remaining half with a constant velocity of 60 kmph. The average velocity of the car in kmph is
(a) 40 (b) 45
(c) 48 (d) 50
(e) 52.

10. Velocity-time (v-t) graph for a moving object is shown in the figure. Total displacement of the object during the time interval when there is non-



zero acceleration and retardation is

(a) 60 m (b) 50 m

(c) 30 m (d) 40 m

(e) 65 m.

11. When a ceiling fan is switched on, it makes 10 revolutions in the first 3 seconds. Assuming a uniform angular acceleration, how many rotations it will make in the next 3 seconds?

(a) 10 (b) 20

(c) 30 (d) 40

(e) 60.

12. If $\vec{A}$ and $\vec{B}$ are non-zero vectors which obey the relation $|\vec{A}+\vec{B}| = |\vec{A}-\vec{B}|$, then the angle between them is

(a) 0° (b) 60°

(c) 90° (d) 120°

(e) 180°.

13. A book is lying on the table. What is the angle between the action of the book on the table and the reaction of the table on the book?

(a) 0° (b) 30°

(c) 45° (d) 90°

(e) 180°.

14. A man of mass 60 kg is standing on a spring balance inside a lift. If the lift falls freely downwards, then the reading of the spring balance will be

(a) zero (b) 60 kgf

(c) < 60 kgf (d) > 60 kgf

(e) 60 kg + weight of the spring.

15. Which one of the following is not a conservative force?

(a) gravitational force

(b) electrostatic force between two charges

(c) magnetic force between two magnetic dipoles

(d) frictional force (e) force between nucleons.

16. An 8 kg metal block of dimension 16 cm × 8 cm × 6 cm is lying on a table with its face of largest area touching the table. If $g = 10\ \text{ms}^{-2}$ the minimum amount of work done in making it stand with its length vertical is

(a) 0.4 J (b) 6.4 J

(c) 64 J (d) 4 J

(e) 12.8 J.

17. A solid cylinder of mass 20 kg has length 1 m and radius 0.2 m. Then its moment of inertia (in kg m^2) about its geometrical axis is (in kg m^2)

(a) 0.8 (b) 0.4

(c) 0.2 (d) 20.2

(e) 20.4

18. A cricket bat is cut at the location of its center of mass as shown. Then

(a) the two pieces will have the same mass

(b) the bottom piece will have larger mass

(c) the handle piece will have larger mass

(d) mass of handle piece is double the mass of bottom piece

(e) cannot say.

19. A simple pendulum is taken from the equator to the pole. Its period

(a) decreases (b) increases

(c) remains the same

(d) decreases and then increases

(e) becomes infinity.

20. The depth at which the value of acceleration due to gravity becomes $1/n$ times the value at the surface is (R be the radius of the earth)

(a) R/n (b) R/n^2

(c) $\dfrac{R(n-1)}{n}$ (d) $\dfrac{Rn}{(n-1)}$

(e) Rn

21. Construction of submarines is based on

(a) Archimedes' principle

(b) Bernoulli's theorem (c) Pascal's law

(d) Newton's laws (e) Boyle's law.

22. Water rises up to a height h in a capillary tube of certain diameter. This capillary tube is replaced by a similar tube of half the diameter. Now the water will rise to the height of

(a) $4h$ (b) $3h$

(c) $2h$ (d) h

(e) $1/2\ h$.

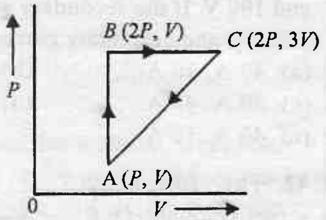
23. An incompressible fluid flows steadily through a cylindrical pipe which has radius $2r$ at point A and radius r at B further along the flow direction. If the velocity at point A is v, its velocity at point B is

(a) $2v$ (b) v

(c) $v/2$ (d) $4v$
(e) $8v$.

24. When water is heated from 0°C to 10°C, its volume
(a) increases (b) decreases
(c) does not change
(d) first decreases and then increases
(e) first increases and then decreases.

25. An ideal gas is taken through a cycle $ABCA$ as shown in the PV diagram. The work done during the cycle is

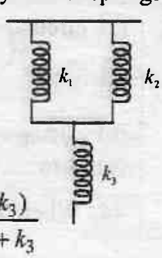


(a) $\frac{1}{2}PV$
(b) $2PV$ (c) $4PV$
(d) PV (e) zero.

26. A hot liquid kept in a beaker cools from 80°C to 70°C in two minutes. If the surrounding temperature is 30°C, then the time of cooling of the same liquid from 60°C to 50°C is
(a) 240 s (b) 360 s
(c) 480 s (d) 216 s
(e) 264 s.

27. Which of the following is not characteristics of simple harmonic oscillation?
(a) the motion is periodic
(b) the motion is along straight line about the mean position
(c) the acceleration of the particle is directed towards the extreme positions
(d) the oscillations are responsible for the energy transportation
(e) the period is given by $T = 2\pi\sqrt{\frac{m}{k}}$ where the symbols have usual meaning.

28. The resultant spring constant of the system of springs shown below is

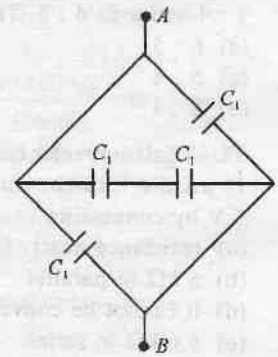


(a) $\frac{(k_1+k_2)}{k_1+k_2+k_3}$
(b) $\frac{(4k_1+2k_2)(k_3)}{k_1+k_2+k_3}$
(c) $\frac{(k_1+k_2)}{2(k_1+k_2+k_3)}$ (d) $\frac{(k_1\,k_2\,k_3)}{k_1+k_2+k_3}$
(e) $\frac{(k_1+k_2)(k_3)}{k_1+k_2+k_3}$.

29. A source of sound of frequency 500 Hz is moving towards an observer with velocity 30 ms^{-1}. The speed of sound is 330 ms^{-1}. The frequency heard by the observer will be
(a) 545 Hz (b) 580 Hz
(c) 458.3 Hz (d) 550 Hz
(e) 560 Hz.

30. A stone is dropped into a lake from a tower of 500 m high. The sound of the splash will be heard at the top of the tower approximately after (given velocity of sound = 330 ms^{-1}) a time of
(a) 11.5 seconds (b) 1.5 seconds
(c) 10 seconds (d) 14 seconds
(e) 21 seconds.

31. Four identical capacitors are connected as shown in diagram. When a battery of 6 V is connected between A and B, the charge stored is found to be 1.5 μC. The value of C_1 is



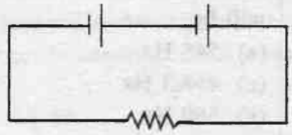
(a) 2.5 μF
(b) 15 μF
(c) 1.5 μF
(d) 1 μF
(e) 0.1 μF.

32. A 10 μF capacitor is charged to a potential difference of 1000 V. The terminals of the charged capacitor are disconnected from the power supply and connected to the terminals of an uncharged 6 μF capacitor. What is the final potential difference across each capacitor?
(a) 167 V (b) 100 V
(c) 625 V (d) 250 V
(e) 750 V.

33. A particle of mass m carrying charge q is released from rest in a uniform electric field of intensity E. The kinetic energy acquired by the particle after moving a distance of x is (neglect gravitational force)
(a) qEx (b) qEx^2
(c) qE^2x (d) q^2Ex
(e) q^2E^2x.

34. The electric field E, current density j and conductivity σ of a conductor are related as
(a) $\sigma = E/j$ (b) $\sigma = j/E$
(c) $\sigma = jE$ (d) $\sigma = 1/jE$
(e) $\sigma = j^2E$.

35. Two cells of same emf E but different internal resistances r_1 and r_2 are connected in series to an external resistance R. The value of R for which the potential difference across the first cell is zero is given by



(a) $R = r_1 - r_2$ (b) $R = r_1 + r_2$
(c) $R = r_1 r_2$ (d) $R = r_1/r_2$
(e) $R = r_1 = r_2$.

36. Two wires that are made up of two different materials whose specific resistances are in the ratio 2 : 3, length 3 : 4 and area 4 : 5. The ratio of their resistances is
(a) 6 : 5 (b) 6 : 8
(c) 5 : 8 (d) 1 : 2
(e) 1 : 4

37. A galvanometer has 30 divisions and a sensitivity 16 μA/div. It can be converted into a voltmeter to read 3 V by connecting
(a) resistance nearly 6 kΩ in series
(b) 6 kΩ in parallel (c) 500 Ω in series
(d) it cannot be converted
(e) 6.6 kΩ in series.

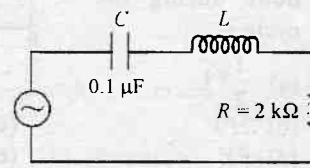
38. An alpha particle and a proton of same velocity enters a uniform magnetic field at right angles to it. The ratio of the radii of the circular paths of alpha particle and the proton respectively is
(a) 1 : 2 (b) 4 : 1
(c) 1 : 4 (d) 2 : 3
(e) 2 : 1

39. Two long parallel wires P and Q are both perpendicular to the plane of the paper with distance 5 m between them. If P and Q carry current of 2.5 amp and 5 amp respectively in the same direction, then the magnetic field at a point half way between the wires is
(a) $\frac{\sqrt{3}\mu_0}{2\pi}$ (b) $\frac{\mu_0}{\pi}$
(c) $\frac{3\mu_0}{2\pi}$ (d) $\frac{\mu_0}{2\pi}$
(e) $\frac{\sqrt{3}\mu_0}{\pi}$

40. An ac source of frequency 50 Hz is connected in series to an inductance of 0.5 H and resistance of 157 ohms. The phase difference between current and voltage is
(a) 90° (b) 60°
(c) 75° (d) 45°
(e) 30°.

41. A transformer with efficiency 80% works at 4 kW and 100 V. If the secondary voltage is 200 V, then the primary and secondary currents are respectively
(a) 40 A, 16 A (b) 16 A, 40 A
(c) 20 A, 40 A (d) 40 A, 20 A
(e) 40 A, 10 A.

42. The following series resonant LCR circuit has a quality factor (Q-factor) 0.4 and a bandwidth of 1.3 kHz. The value of inductance is then



(a) 0.1 H (b) 0.94 H
(c) 2 H (d) 10 H
(e) 5 H.

43. Which one of the following is not electromagnetic in nature?
(a) X-rays (b) gamma rays
(c) cathode rays (d) infrared rays
(e) microwaves.

44. A glass slab of thickness 3 cm and refractive index 3/2 is placed on ink mark on a piece of paper. For a person looking at the mark at a distance 5.0 cm above it, the distance of the mark will appear to be
(a) 3.0 cm (b) 4.0 cm
(c) 4.5 cm (d) 5.0 cm
(e) 3.5 cm.

45. A fish looking from within water sees the outside world through a circular horizon. If the fish is $\sqrt{7}$ m below the surface of water, what will be the radius of the circular horizon?
(a) 3 m (b) $\frac{3}{\sqrt{7}}$ m
(c) $\sqrt{7}$ m (d) $3\sqrt{7}$ m
(e) 4 m.

46. When the angle of incidence on a material is 60°,

the reflected light is completely polarized. The velocity of the refracted ray inside the material is (in ms^{-1})

(a) 3×10^8 (b) $\left(\frac{3}{\sqrt{2}}\right)\times 10^8$

(c) $\sqrt{3}\times 10^8$ (d) 0.5×10^8

(e) 0.75×10^8.

47. The wavelength of the matter wave is independent of

(a) mass (b) velocity

(c) momentum (d) charge

(e) frequency.

48. In a sample of radioactive material, what fraction of the initial number of active nuclei will remain un-disintegrated after half of a half-life of the sample?

(a) $\frac{1}{4}$ (b) $\frac{1}{2\sqrt{2}}$

(c) $\frac{1}{\sqrt{2}}$ (d) $2\sqrt{2}$

(e) $\sqrt{2}$

SOLUTIONS

1. (d) : $E = mc^2 = 1 \times 10^{-6} \times (3 \times 10^8)^2$
$= 10^{-6} \times 9 \times 10^{16} = 9 \times 10^{10}$ J.

2. (c) : When positive terminal of battery is connected to the p-side and negative terminal to the n-side then diode is said to be forward biased while when negative terminal of battery is connected to p-side and positive terminal to the n-side then diode is said to be reverse biased.

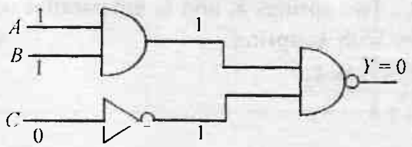
3. (b) : Let the number of electrons emitted per second at emitter be x.

$\therefore \quad ex \times \frac{90}{100} = 10$ mA

$I_E = ex = \frac{100}{9}$ mA $= 11.1$ mA

Also, $I_E = I_B + I_C$ or, $I_B = 1.1$ mA.

4. (e) :



5. (b) : The process of changing the frequency of a carrier wave (modulated wave) in accordance with the audio frequency signal (modulating wave) is known as frequency modulation (FM).

6. (d) : Following are the problems which are faced while transmitting audio signals directly.

(i) These signals are relatively of short range.

(ii) If everybody started transmitting these low frequency signals directly, mutual interference will render all of them ineffective.

(iii) Size of antenna required for their efficient radiation would be larger *i.e.* about 75 km.

7. (e) : Remote sensing is the technique to collect information about an object in respect of its size, colour, nature, location, temperature etc. without physically touching it. There are some areas or location which are inaccessible. So to explore these areas or locations, a technique known as remote sensing is used. Remote sensing is done through a satellite.

8. (d) : Energy = force × distance

9. (c) : $v = \frac{\text{total distance}}{\text{total time}} = \frac{(d/2)+(d/2)}{\frac{d/2}{v_1}+\frac{d/2}{v_2}} = \frac{2v_1v_2}{v_1+v_2}$

$$= \frac{40\times 60\times 2}{40+60} = 48 \text{ kmph.}$$

10. (b) : Between time interval 20 s to 40 s there is non-zero acceleration and retarding.

$\therefore$ Distance travelled during this interval
= area between interval 20 s to 40 s

$= \frac{1}{2}\times$ base × height + area of rectangle

$= \frac{1}{2}\times 20\times 3 + 20\times 1 = 30 + 20 = 50$ m.

11. (c) : Angle turned through in 3 seconds
$= 2\pi \times 10 = 20\pi$

But, $\theta = \omega_0 t + \frac{1}{2}\alpha t^2 \Rightarrow 20\pi = 0 + \frac{1}{2}\alpha\cdot 9$

$\Rightarrow \quad \alpha = \frac{40\pi}{9}$ radians/s^2

$\omega_t = \omega_0 + \alpha t\,; \quad \omega_{3s} = 0 + \frac{40\pi\times 3}{9} = \frac{40\pi}{3}$

$\therefore$ θ from 6 s to 3 s $= \frac{40\pi}{3}\times 3 + \frac{1}{2}\frac{40\pi}{9}\times 9 = 60\pi$

$\therefore$ The number of revolutions made from 3s to 6s
$= 60\pi/2\pi = 30$.

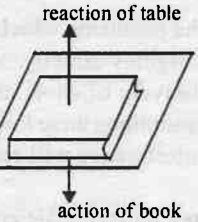
12. (c) : $|\vec{A}+\vec{B}| = |\vec{A}-\vec{B}|$

$|\vec{A}|^2 + |\vec{B}|^2 + 2|\vec{A}||\vec{B}|\cos\theta = |\vec{A}|^2 + |\vec{B}|^2 - 2|\vec{A}||\vec{B}|\cos\theta$

$\Rightarrow \quad 4|\vec{A}||\vec{B}|\cos\theta = 0$

$\therefore \quad \cos\theta = 0 \Rightarrow \theta = 90°$.

13. **(e)** :



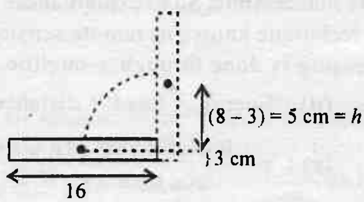
14. **(a)** : Inside a freely falling lift, as the spring balance is attached to the lift, with respect to the lift, the mass is weightless.

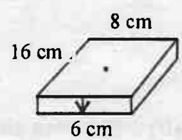
15. **(d)** : Force of friction is not conserved. This is not a conservative force.

16. **(d)** : Work done = mgh

The height of centre of mass initially = 3 cm

The height when the block is vertical = 8 cm





$\therefore$ Work done = mgh

$= 8 \times 10 \times (5 \times 10^{-2})$

$= 400 \times 10^{-2} = 4$ J.

17. **(b)** : The moment of inertia of cylinder about the geometrical axis = $MR^2/2$

$$= \frac{20 \times (0.2)^2}{2} = 0.4 \text{ kgm}^2 .$$

18. **(b)** : Centre of mass is closer to massive part of the body therefore the bottom piece of bat have larger mass.

19. **(a)** : $T = 2\pi\sqrt{\frac{l}{g}}$

As we go from equator to pole the value of g increases. Therefore value of time period of simple pendulum decreases.

20. **(c)** : Acceleration due to gravity at a depth d

$$= g\left(1 - \frac{d}{R}\right)$$

$$\therefore \quad \frac{g}{n} = g\left(1 - \frac{d}{R}\right) \Rightarrow \frac{1}{n} = \left(1 - \frac{d}{R}\right)$$

$$\Rightarrow \quad 1 - \frac{1}{n} = \frac{d}{R} \quad \Rightarrow d = \frac{R(n-1)}{n}.$$

21. **(a)**

22. **(c)** : The height h through which a liquid will rise in a capillary tube of radius r is given by $h = \frac{2s\cos\theta}{r\rho g}$

$\therefore \quad h \propto 1/r.$

$\therefore$ When diameter of tube is half of original then water will rise to a height $2h$.

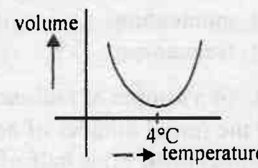
23. **(d)** : From equation of continuity

av = a constant

$a_A v_A = a_B v_B$

$\Rightarrow \pi(2r)^2 v = \pi r^2 v_B \quad \Rightarrow \quad v_B = 4v.$

24. **(d)** : As the temperature of water increases its volume decreases till 4°C, at this temperature volume of water is minimum. On further increase in the temperature, volume starts increasing.



25. **(d)** : Work done = area enclosed by triangle

$$= \frac{1}{2} \times (2P - P)(3V - V) = \frac{1}{2} \times P \times 2V = PV.$$

26. **(d)** : From Newton's law of cooling,

$$\frac{\theta_1 - \theta_2}{t} = k\left(\frac{\theta_1 + \theta_2}{2} \quad \theta_0\right)$$

When liquid is cooled from 80°C to 70°C

$$\frac{80-70}{120} = k\left[\frac{80+70}{2} - 30\right]$$

$$\Rightarrow \quad k = \frac{10}{120 \times 45} \qquad \text{... (i)}$$

When liquid is cooled from 60°C to 50°C

$$\frac{60-50}{t} = k\left[\frac{60+50}{2} - 30\right]$$

$$\text{or, } \quad \frac{10}{t} = \frac{10}{120 \times 45} \times 25 \Rightarrow t = \frac{120 \times 45}{25} = 216 \text{ s.}$$

[using (i)]

27. **(c)** : Acceleration $\propto$ – displacement

The direction of acceleration is always directed towards the equilibrium position.

28. **(e)** : Two springs k_1 and k_2 are parallel which are in series with k_3 spring.

$$\therefore \quad \frac{(k_1 + k_2) \times k_3}{k_1 + k_2 + k_3}.$$

29. **(d)** : Apparent frequency $= \frac{v}{v - v_s}\upsilon$

$$= \frac{330}{330 - 30} \times 500 = \frac{330}{300} \times 500$$

$\upsilon' = 550$ Hz.

. **(a) :** The time taken by stone to reach lake

$$S = ut_1 + \frac{1}{2}gt_1^2$$

$$500 = 0 \times t_1 + \frac{1}{2} \times 10 \times t_1^2$$

$t_1^2 = 100\text{s} \Rightarrow t_1 = 10$ s.

he time taken by sound to reach tower

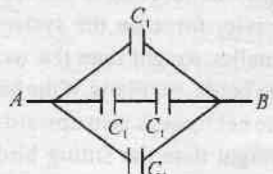
$$t_2 = \frac{s}{v} = \frac{500}{330} \simeq 1.5 \text{ s.}$$

Total time taken by sound of splash to be heard

$t = t_1 + t_2 = 10 + 1.5$ s $= 11.5$ s.

l. **(e) :** The capacitance across A and B

$$= \frac{C_1}{2} + C_1 + C_1 = \frac{5}{2}C_1$$



This is the equivalent diagram

s $Q = CV$,

$$1.5\,\mu\text{C} = \frac{5}{2}C_1 \times 6$$

$$\Rightarrow C_1 = \frac{1.5}{15} \times 10^{-6} = 0.1 \times 10^{-6}\text{F} = 0.1\ \mu\text{F}.$$

2. **(c) :** After charging, total charge on the capacitor

$Q = CV$, where $C = 10\ \mu$F

$= 10 \times 10^{-6}$ F $\times 1000$ V $= 10^{-2}$ C.

When this charged capacitor is connected to uncharged capacitor then total charge remains same.

$Q = Q_1 + Q_2$

$10^{-2} = (C_1 + C_2)V$

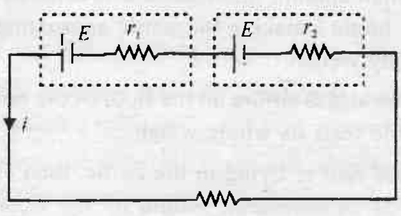
$$\Rightarrow V = \frac{10^{-2}}{16 \times 10^{-6}} \Rightarrow V = 625 \text{ V.}$$

3. **(a) :** Kinetic energy = force × distance

$= Eq \times x = qEx$.

4. **(b)**

5. **(a) :**



From circuit, $V_1 + V_2 = iR$

$E - ir_1 + E - ir_2 = iR$. Also $ir_1 = E$ (given)

$\therefore ir_1 - ir_1 + ir_1 - ir_2 = iR \Rightarrow R = r_1 - r_2$.

Alternative : $i = \dfrac{2E}{r_1 + r_2 + R} = \dfrac{E}{r_1}$

As $ir_1 = E$ (given), $i = \dfrac{E}{r_1}$

$\Rightarrow 2r_1 = r_1 + r_2 + R \Rightarrow R = r_1 - r_2$.

36. **(c) :** Resistance $= \rho\dfrac{l}{A}$

$$\therefore \frac{R_1}{R_2} = \frac{\rho_1}{\rho_2} \times \frac{l_1}{l_2} \times \frac{A_2}{A_1} = \frac{2}{3} \times \frac{3}{4} \times \frac{5}{4} = \frac{5}{8}.$$

37. **(a) :** $(R + G)I_g = V$

$$(R + G) = \frac{V}{I_g}$$

$$= \frac{3}{30 \times 16 \times 10^{-6}} = 6.25\ \text{k}\Omega.$$

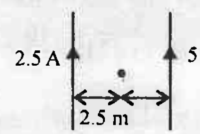
$\therefore$ Value of R is nearly equal to 6 kΩ.

This is connected in series in a voltmeter.

38. **(e) :** $r = \dfrac{mv}{qB}$

$$\frac{r_\alpha}{r_p} = \frac{m_\alpha}{q_\alpha} \times \frac{q_p}{m_p} = \frac{4m_p}{2e} \times \frac{e}{m_p} = \frac{2}{1}.$$

39. **(d) :** $B = \dfrac{\mu_0}{4\pi}\left[\dfrac{5}{2.5} - \dfrac{2.5}{2.5}\right]$



$$= \frac{\mu_0}{2\pi} \times \frac{2.5}{2.5} = \frac{\mu_0}{2\pi}.$$

40. **(d) :** $\tan\phi = \dfrac{X_L}{R} = \dfrac{\omega L}{R} = \dfrac{2\pi \times 50 \times 0.5}{157}$

where ϕ is the phase difference between current and voltage.

$\tan\phi \simeq 1$, $\therefore \phi \simeq 45°$.

41. **(a) :** $\eta = \dfrac{\text{output power}}{\text{input power}} = \dfrac{E_s I_s}{E_p I_p}$

$$\frac{80}{100} = \frac{200 \times I_s}{4 \times 10^3}$$

$$\Rightarrow I_s = \frac{80}{100} \times \frac{4 \times 1000}{200} = 16 \text{ A.}$$

Also, $E_p I_p = 4$ KW

$$\Rightarrow I_p = \frac{4 \times 10^3}{100} = 40 \text{ A.}$$

42. $Q=\frac{1}{R}\sqrt{\frac{L}{C}} \Rightarrow \frac{L}{C}=(O\times R)^2$

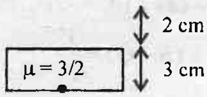
$\Rightarrow L = (0.4 \times 2 \times 10^3)^2 \times 0.1 \times 10^{-6} = 0.64$ H.

None of the given answer is correct.

43. (c) : Cathode rays are invisible fast moving streams of electrons emitted by the cathode of a discharge tube which is maintained at a pressure of about 0.01 mm of mercury.

44. (b) : The apparent depth of ink mark

$=\frac{\text{real depth}}{\mu}$

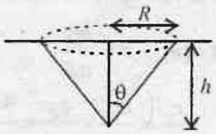


$=\frac{3}{3/2}=2$ cm.

Thus for person mark is at a distance = 2 + 2 = 4 cm.

45. (a) : From condition of total internal reflection,

$\sin\theta=\frac{1}{\mu}$



$\Rightarrow \frac{R}{\sqrt{R^2+h^2}}=\frac{1}{\mu}$

$\Rightarrow R^2+h^2=(R\times\mu)^2$

$\Rightarrow R^2+(\sqrt{7})^2=\frac{16}{9}\times R^2 \quad \left(\mu_w=\frac{3}{4}\right)$

$\Rightarrow 7=\frac{16}{9}R^2-R^2 \Rightarrow \frac{7}{9}R^2-7$

$\Rightarrow R^2 = 9 \Rightarrow R = 3$ m.

46. (c) : From Brewster's law,

$\mu = \tan i_p \Rightarrow \frac{c}{v}=\tan 60°$

$\Rightarrow v=\frac{3\times10^8}{\sqrt{3}}=\sqrt{3}\times10^8$ m/s.

47. (d)

48. (c) : $\frac{N}{N_0}=\left(\frac{1}{2}\right)^n$

where $n=\frac{T}{T_{1/2}}$. Also $T=\frac{T_{1/2}}{2}$ given.

$\therefore n = 1/2$.

$\therefore \frac{N}{N_0}=\left(\frac{1}{2}\right)^{1/2}=\frac{1}{\sqrt{2}}$.

Is a flying bird in a bottle lighter than it sitting on the bottom?

When the cap is sealed, the bird and the bottle form a sealed system. As long as the bird is not accelerating up or down (ie sitting on the floor or flying level) the center of mass of the system is moving with a constant vertical velocity.

On the otherhand, if the bird is accelerating downwards, then so is the center of mass. The net force on the system must be a small downwards force - so the upwards force from the scale is slightly less than the gravity force on the system. Thus the scale reads a smaller weight than the weight of the sitting bird in the bottle. Similarly, if the bird is accelerating upwards, the net force is also upwards - the scale reads a higher weight than the sitting bird.

Physically, what is happening is that when the bird is flying steadily, it is pushing air downwards with its wings to keep it up in the air. This causes a wind to flow downwards which impacts the bottom of the bottle. pushing it down. This downwards flow of air also creates a slight vacuum above the wings, which creates a small force downwards on the ceiling of the bottle.

The downwards force from the air on the bottle pushes down with exactly the weight of the bird (if the bird is not accelerating), making the scale push upwards with an extra force.

When the cap is opened, the system stops being closed and the parts really do need to be considered sperarately, but we can get an idea about what happens by thinking about it a little:

1. If the bird is "in" the open bottle but very, very, far above the tops of the walls of the bottle, only a small amount of its down draft will be felt by the bottle - making the bottle approximately its empty weight.
2. If the bird is sitting on the floor of the bottle, the bottle feels its whole weight.
3. If the bird is flying in the bottle, then although all of its downdraft should hit the floor of the bottle, the small downwards force on the ceiling created by the slight vacuum made by the wings is absent, making the bottle lighter than the closed bottle.

International Physics Olympiad

PROBLEMS & SOLUTIONS

Q. The most frequent orbital manoeuvres performed by spacecraft consist of velocity variations along the direction of flight, namely accelerations to reach higher orbits or brakings done to initiate re-entering in the atmosphere. In this problem we will study the orbital variations when the engine thrust is applied in a radial direction.

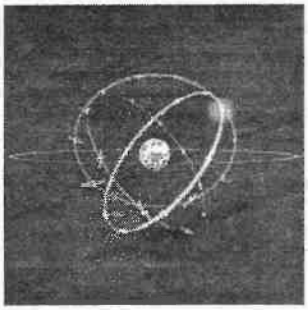


Image: ESA

To obtain numerical values use:
Earth radius $R_T = 6.37 \times 10^6$ m, Earth surface gravity $g = 9.81$ m/s^2, and take the length of the sidereal day to be $T_0 = 24.0$ h.

We consider a geosynchronous communications satellite of mass m placed in an equatorial circular orbit of radius r_0. These satellites have an "apogee engine" which provides the tangential thrusts needed to reach the final orbit.

Marks are indicated at the beginning of each subquestion, in parenthesis.

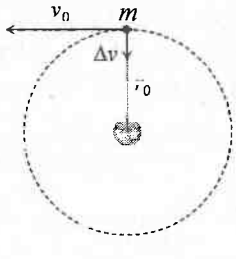
Question 1

1.1 Compute the numerical value of r_0.

1.2 Give the analytical expression of the velocity v_0 of the satellite as a function of g, R_T, and r_0, and calculate its numerical value.

1.3 Obtain the expressions of its angular momentum L_0 and mechanical energy E_0, as functions of v_0, m, g and R_T.

Once this geosynchronous circular orbit has been reached (see Figure F-1), the satellite has been stabilised in the desired location, and is being readied to do its work, an error by the ground controllers causes the apogee engine to be fired again. The thrust happens to be directed towards the Earth and, despite the quick reaction of the ground crew to shut the engine off, an unwanted velocity variation Δv is imparted on the satellite. We characterize this boost by the parameter $\beta = \Delta v / v_0$. The duration of the engine burn is always negligible with respect to any other orbital times, so that it can be considered as instantaneous.



F-1

Question 2

Suppose $\beta < 1$.

2.1 Determine the parameters of the new orbit, semi-latus-rectum l and eccentricity ε, in terms of r_0 and β.

2.2 Calculate the angle α between the major axis of the new orbit and the position vector at the accidental misfire.

2.3 Give the analytical expressions of the perigee r_{min} and apogee r_{max} distances to the Earth centre, as functions of r_0 and β, and calculate their numerical values for $\beta = 1/4$.

2.4 Determine the period of the new orbit, T, as a function of T_0 and β, and calculate its numerical value for $\beta = 1/4$.

Question 3

3.1 Calculate the minimum boost parameter, β_{esc}, needed for the satellite to escape Earth gravity.

3.2 Determine in this case the closest approach of the satellite to the Earth centre in the new trajectory, r'_{min}, as a function of r_0.

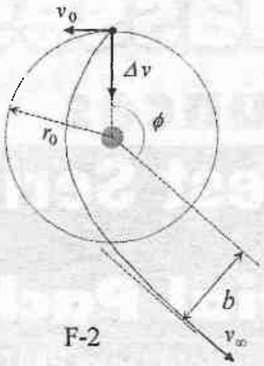
Question 4

Suppose $\beta > \beta_{esc}$.

4.1 (1.0) Determine the residual velocity at the infinity, v_∞, as a function of v_0 and β.

4.2 (1.0) Obtain the "impact parameter" b of the asymptotic escape direction in terms of r_0 and β. (See Figure F-2).

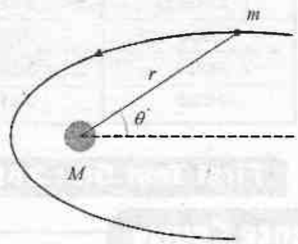
4.3 (1.0 + 0.2) Determine the angle ϕ of the asymptotic escape direction in terms of β. Calculate its numerical value for $\beta = \frac{3}{2}\beta_{esc}$.



F-2

HINT

Under the action of central forces obeying the inverse-square law, bodies follow trajectories described by ellipses, parabolas or hyperbolas. In the approximation $m << M$ the gravitating mass M is at one of the focuses. Taking the origin at this focus, the general polar equation of these curves can be written as (see Figure F-3)



F-3

$$r(\theta) = \frac{l}{1 - \varepsilon\cos\theta}$$

where l is a positive constant named the *semi-latus-rectum* and ε is the eccentricity of the curve. In terms of constants of motion:

$$l = \frac{L^2}{GMm^2} \quad \text{and} \quad \varepsilon = \left(1 + \frac{2EL^2}{G^2M^2m^3}\right)^{1/2}$$

where G is the Newton constant, L is the modulus of the angular momentum of the orbiting mass, with respect to the origin, and E is its mechanical energy, with zero potential energy at infinity.

We may have the following cases:

i) If $0 < \varepsilon < 1$, the curve is an ellipse (circumference for $\varepsilon = 0$).

ii) If $\varepsilon = 1$, the curve is a parabola.

iii) If $\varepsilon > 1$, the curve is a hyperbola.

SOLUTIONS

1.1 and 1.2

$$G\frac{M_T m}{r_0^2} = m\frac{v_0^2}{r_0}; \quad v_0 = \frac{2\pi r_0}{T_0}; \quad g = \frac{GM_T}{R_T^2}$$

$$\Rightarrow \begin{cases} r_0 = \left(\dfrac{gR_T^2 T_0^2}{4\pi^2}\right)^{1/3} & \Rightarrow r_0 = 4.22\times10^7 \text{ m} \\ v_0 = R_T\sqrt{\dfrac{g}{r_0}} & \Rightarrow v_0 = 3.07\times10^3 \text{ m/s} \end{cases}$$

1.3 $L_0 = r_0 m v_0 = \frac{gR_T^2}{v_0^2} m v_0 \Rightarrow L_0 = \frac{mgR_T^2}{v_0}$.

$$E_0 = \frac{1}{2}mv_0^2 - G\frac{M_T m}{r_0} = \frac{1}{2}mv_0^2 - \frac{gR_T^2 m}{r_0}$$

$$= \frac{1}{2}mv_0^2 - mv_0^2 \Rightarrow E_0 = -\frac{1}{2}mv_0^2.$$

2.1 The value of the *semi-latus-rectum* l is obtained taking into account that the orbital angular momentum is the same in both orbits. That is

$$l = \frac{L_0^2}{GM_T m^2} = \frac{m^2 g^2 R_T^4}{v_0^2}\frac{1}{gR_T^2 m^2} = \frac{gR_T^2}{v_0^2} = r_0$$

$\Rightarrow l = r_0$.

The eccentricity value is

$$\varepsilon^2 = 1 + \frac{2EL_0^2}{G^2 M_T^2 m^3}$$

where E is the new satellite mechanical energy.

$$E = \frac{1}{2}m\left(v_0^2 + \Delta v^2\right) - G\frac{M_T m}{r_0}$$

$$= \frac{1}{2}m\Delta v^2 + E_0 = \frac{1}{2}m\Delta v^2 - \frac{1}{2}mv_0^2$$

That is $E = \frac{1}{2}mv_0^2\left(\frac{\Delta v^2}{v_0^2} - 1\right) = \frac{1}{2}mv_0^2(\beta^2 - 1)$.

Combining both, one gets $\varepsilon = \beta$.

This is an elliptical trajectory because $\varepsilon = \beta < 1$.

2.2 The initial and final orbits cross at P, where the satellite engine fired instantaneously (see figure 4). At this point

$$r(\theta = \alpha) = r_0 = \frac{r_0}{1 - \beta\cos\alpha} \Rightarrow \alpha = \frac{\pi}{2}.$$

2.3 From the trajectory expression one immediately obtains that the maximum and minimum values of r

correspond to $\theta = 0$ and $\theta = \pi$ respectively (see figure 4).

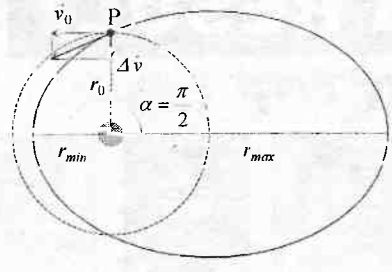


Figure 4

Hence, they are given by

$$r_{max} = \frac{l}{1-\varepsilon}, \quad r_{min} = \frac{l}{1+\varepsilon}.$$

i.e. $r_{max} = \frac{r_0}{1-\beta}$ and $r_{min} = \frac{r_0}{1+\beta}$.

For $\beta = 1/4$, one gets

$$r_{max} = 5.63 \times 10^7 \text{ m}; \quad r_{min} = 3.38 \times 10^7 \text{ m}.$$

The distances r_{max} and r_{min} can also be obtained from mechanical energy and angular momentum conservation, taking into account that $\vec{r}$ and $\vec{v}$ are orthogonal at apogee and at perigee.

$$E = \frac{1}{2} m v_0^2 (\beta^2 - 1) = \frac{1}{2} m v^2 - \frac{g R_T^2 m}{r}$$

$$L_0 = \frac{m g R_T^2}{v_0} = m v r$$

What remains of them, after eliminating v, is a second-degree equation whose solutions are r_{max} and r_{min}.

2.4 By the third Kepler's law, the period T in the new orbit satisfies that

$$\frac{T^2}{a^3} = \frac{T_0^2}{r_0^3}$$

where a, the semi-major axis of the ellipse, is given by

$$a = \frac{r_{max} + r_{min}}{2} = \frac{r_0}{1-\beta^2}$$

Therefore, $T = T_0(1 - \beta^2)^{-3/2}$.

For $\beta = 1/4$, $T = T_0 \left(\frac{15}{16}\right)^{-3/2} = 26.4$ h.

3.1 Only if the satellite follows an open trajectory it can escape from the earth gravity attraction. Then, the orbit eccentricity has to be equal or larger than one. The minimum boost corresponds to a parabolic trajectory, with $\varepsilon = 1$.

$$\varepsilon = \beta \quad \Rightarrow \quad \beta_{esc} = 1$$

This can also be obtained by using that the total satellite energy has to be zero to reach infinity ($E_p = 0$) without residual velocity ($E_k = 0$).

$$E = \frac{1}{2} m v_0^2 (\beta_{esc}^2 - 1) = 0 \quad \Rightarrow \quad \beta_{esc} = 1$$

This also arises from $T = \infty$ or from $r_{max} = \infty$.

3.2 Due to $\varepsilon = \beta_{esc} = 1$, the polar parabola equation is

$$r = \frac{l}{1-\cos\theta}$$

where the semi-latus-rectum continues to be $l = r_0$. The minimum earth-satellite distance corresponds to $\theta = \pi$, where $r'_{min} = r_0/2$.

This also arises from energy conservation (for $E = 0$) and from the equality between the angular momenta (L_0) at the initial point P and at maximum approximation, where $\vec{r}$ and $\vec{v}$ are orthogonal.

4.1 If the satellite escapes to infinity with residual velocity v_∞, by energy conservation,

$$E = \frac{1}{2} m v_0^2 (\beta^2 - 1) = \frac{1}{2} m v_\infty^2$$

$$\Rightarrow \quad v_\infty = v_0 (\beta^2 - 1)^{1/2}.$$

4.2 As $\varepsilon = \beta > \beta_{esc} = 1$, the satellite trajectory will be a hyperbola. The satellite angular momentum is the same at P than at the point where its residual velocity is v_∞ (figure 5), thus $m v_0 r_0 = m v_\infty b$

So, $b = r_0 \frac{v_0}{v_\infty}$

$$\Rightarrow \quad b = r_0 (\beta^2 - 1)^{-1/2}.$$

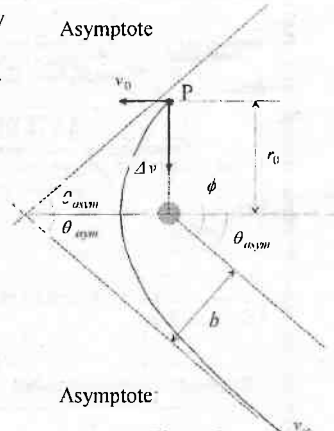


Figure 5

4.3 The angle between each asymptote and the hyperbola axis is that appearing in its polar equation in the limit $r \to \infty$. This is the angle for which the equation denominator vanishes.

$$1 - \beta \cos\theta_{asym} = 0 \quad \Rightarrow \quad \theta_{asym} = \cos^{-1}(1/\beta)$$

According to figure 5,

$$\phi = \frac{\pi}{2} + \theta_{asym} \quad \Rightarrow \quad \phi = \frac{\pi}{2} + \cos^{-1}\left(\frac{1}{\beta}\right).$$

For $\beta = \frac{3}{2}\beta_{esc} = \frac{3}{2}$, one gets $\phi = 138° = 2.41$ rad.

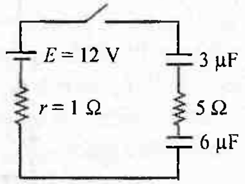
■

Challenging Problems

The problems given here are intended for students preparing for IIT-JEE and students are advised to make a sincere effort of solving these problems before going through the solutions.

By :Shashi Bhushan*

1. Two capacitors in series are charged by a 12.0 V battery that has an internal resistance of 1.0 Ω. There is a 5.0 Ω resistance in series between the capacitors.



(a) What is the time constant of the charging circuit?
(b) After the switch has been closed for a time, determined in part (a), what is the voltage across the 3 μF capacitor? Across 5 Ω resistor?

Soln.: **(a)** R (equivalent) = 1 + 5 = 6 Ω

C (equivalent) = $\dfrac{3\times 6}{3+6} = 2\ \mu\text{F}$.

Time constant, $\tau = RC = 12\ \mu$ sec.

(b) $q = q_0(1 - e^{-t/\tau})$

where $q_0 = EC = 12 \times 2 = 24\ \mu$C

At time $t = \tau$

$q = q_0(1 - e^{-1}) = 0.63q_0 = 15.12\ \mu$C.

Current, $i = \dfrac{dq}{dt} = i_0\, e^{-t/\tau}$

where $i_0 = \dfrac{E}{R} = \dfrac{12\text{ V}}{6\,\Omega} = 2$ A.

∴ At time $t = \tau$, $i = 0.37i_0 = 0.74$ A.

∴ Potential difference across 3 μF

$V_C = \dfrac{q}{3\ \mu F} = 5.04$ volts.

[Note that charge on both the capacitors is same].

Potential difference across 5 Ω

$V_R = i \times 5 = 0.74 \times 5 = 3.70$ V.

---

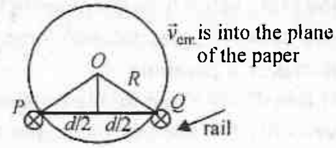
2. A uniform solid ball of radius R rolls without slipping between two horizontal rails such that the horizontal distance is d between two contact points of the rails to the ball.

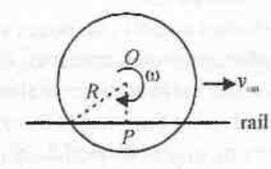
(a) Show that $V_{cm} = \omega\sqrt{R^2 - d^2/4}$.

where ω is angular velocity of the ball.

(b) Now consider a pair of equally inclined rails with a separation $d\ (< 2R)$ and consider a uniform ball starting from rest and descending a vertical distance h while rolling without slipping. Find the speed of centre of mass of the ball at the bottom of the rails.

Soln.: **(a)** The section of the rolling ball perpendicular to the rails and parallel to the rails has been shown. Note that ball is in contact with rail at point P only in the second diagram. (And of course at another point Q opposite P which is not visible).





Since there is no slipping, $\vec{v}_P = 0$

But $\vec{v}_P = \vec{v}_{cm} + \vec{v}_{PO}$ (velocity of P relative to CM)

or, $0 = v_{cm}(\rightarrow) + \omega(\text{OP})(\leftarrow) \Rightarrow v_{cm} = \omega\sqrt{R^2 - d^2/4}$.

(b) While rolling down the inclined rails, the same relation holds between v_{cm} and ω. Since there is no sliding, friction does not perform any work and mechanical energy is conserved.

∴ K.E.$_{\text{at bottom}}$ = P.E.$_{\text{at top}}$

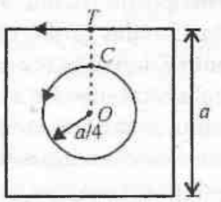
$$\Rightarrow \frac{1}{2}mv_{cm}^2 + \frac{1}{2}\left(\frac{2}{5}mR^2\right)\omega^2 = mgh$$

$$\Rightarrow v_{cm}^2 + \frac{2}{5}\frac{R^2 v_{cm}^2}{R^2 - (d^2/4)} = 2gh$$

$$\Rightarrow v_{cm} = \sqrt{\frac{10gh}{5 + 2\bigg/\left(1 - \dfrac{d^2}{4R^2}\right)}}.$$

---

3. In a park, a toy train moves along a square path of side length a blowing a whistle of frequency 300 Hz. A boy is riding a toy car running on a circular track of radius $a/4$. The centres of the square and the circle coincide. The car moves with a constant speed of 11 m/s. At the initial moment of the train was at T and the car at C. The train



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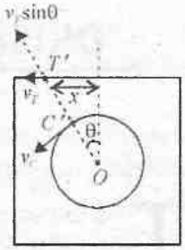
moves such that the points O, C and T always lie on the radial line. Determine the maximum and minimum frequency heard by the boy. Speed of sound is 330 m/s.

Soln.: Consider the situation when train has moved a distance x.



Speed of train,

$$v_T = \frac{dx}{dt} = \frac{d}{dt}\left(\frac{a}{2}\tan\theta\right)$$

$$= \frac{a}{2}\sec^2\theta\frac{d\theta}{dt} = \frac{a}{2}\omega\sec^2\theta.$$

where $\frac{d\theta}{dt} = \omega$ = angular speed of the train = angular speed of car

$$= \frac{11\text{ m/s}}{a/4} = \frac{44}{a}\text{ rad/sec.}$$

$\therefore\quad v_T = 22\sec^2\theta.$

The Doppler shifts depends on velocity of train along the line joining C and T. Note that the velocity of car is always perpendicular to this line and hence has no effect on apparent frequency.

Component of train's velocity along $C'T'$ is

$$v_{Tr} = v_T\sin\theta = 22\sec^2\theta\cdot\sin\theta$$

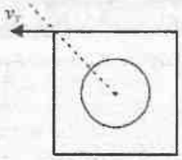
In the position shown minimum frequency will be registered by the boy on the car when v_{Tr} is maximum.

$\Rightarrow$ when $\sin\theta\cdot\sec^2\theta$ is maximum

$\Rightarrow$ when $\theta = 45°$

[$\because$ both $\sin\theta$ and $\sec\theta$ are increasing function when θ changes from 0° to 90°, and 45° is the maximum possible value of θ in this case].

$\therefore$ Minimum frequency is heard when the train is about to reach the corner.

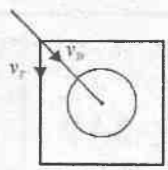


$$v_{Tr} = 22\sec^2 45°\cdot\sin 45°$$

$$= 22\sqrt{2}\text{ m/s}.$$

$$\therefore\quad f_{\min} = 300\left[\frac{330}{330+22\sqrt{2}}\right] = 274.2\text{ Hz}.$$

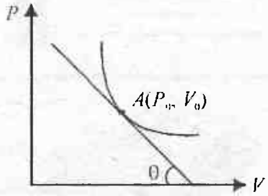
Maximum frequency is heard when the train takes the turn at the corner. In this situation the velocity component of the train is towards the car and is maximum.



$$\therefore\quad f_{\max} = 300\left[\frac{330}{330-22\sqrt{2}}\right] = 331.1\text{ Hz}.$$

---

4. A gas is undergoing an adiabatic process represented by the graph shown in figure. At a certain stage (shown by point A in the graph) the pressure and volume is P_0 and V_0 and the tangent at A makes an angle θ with volume axis as shown. Find the value of molar specific heat of the gas at constant volume using the given information.



Soln.: For a adiabatic process, PV^γ = constant

$$\Rightarrow\quad \gamma PV^{\gamma-1} + V^\gamma\frac{dP}{dV} = 0 \Rightarrow \frac{dP}{dV} = -\frac{\gamma P_0}{V_0}$$

$$\therefore\quad \left(\frac{dP}{dV}\right)_A = -\frac{\gamma P_0}{V_0}$$

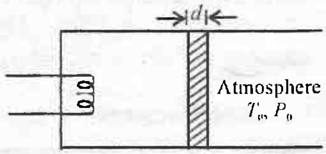
But $\left(\frac{dP}{dV}\right)_A = -\tan\theta$ [from the graph]

$$\therefore\quad \frac{\gamma P_0}{V_0} = \tan\theta \Rightarrow \gamma = \frac{V_0\tan\theta}{P_0}$$

$$\text{Since, } C_V = \frac{R}{\gamma-1} = \frac{R}{\frac{V_0\tan\theta}{P_0}-1} = \frac{RP_0}{V_0\tan\theta - P_0}.$$

---

5. A non conducting cylinder is fitted with a conducting piston of cross sectional area A, thickness d and thermal conductivity K. The cylinder contains a monoatomic gas at atmospheric temperature T_0. The piston is open to the atmosphere (atmospheric pressure = P_0) as shown and can slide without friction. The heater fitted inside the cylinder supplies heat at a constant rate of q and is switched on at $t = 0$.



(a) Find the temperature of the gas as function of time.

(b) Find the maximum volume of the gas if its initial volume is V_0.

Soln.: **(a)** Let the temperature of the gas be T at time t.

Rate of heat supply by heater

= rate of heat absorbed by gas + rate of heat conduction to atmosphere through piston

Heat supplied by heater in time $dt = qdt$

Heat absorbed by gas in time $dt = nC_PdT$

where dT = rise in temperature in time dt.

Note that process is isobaric as gas expands under constant atmospheric pressure.

Heat conducted through piston in time dt

$$= \frac{KA(T-T_0)}{d}dt$$

$$\therefore\quad qdt = nC_PdT + \frac{KA(T-T_0)}{d}dt$$

$$\Rightarrow \quad \frac{5}{2}nR\,dT = \left(q - \frac{KA(T-T_0)}{d}\right)dt$$

$$\Rightarrow \quad \frac{dT}{qd - KA(T-T_0)} = \frac{2}{5nRd}dt$$

Integrating, $\displaystyle\int_{T_0}^{T} \frac{dT}{qd - KA(T-T_0)} = \frac{2}{5nRd}\int_0^t dt$

$$\Rightarrow \quad -\frac{1}{KA}\ln\left[\frac{qd - KA(T-T_0)}{qd}\right] = \frac{2}{5nRd}t$$

$$\Rightarrow \quad 1 - \frac{KA}{qd}(T-T_0) = e^{-\frac{2KAt}{5nRd}}$$

$$\Rightarrow \quad T = T_0 + \frac{qd}{KA}\left[1 - e^{-\frac{2KAt}{5nRd}}\right]$$

(b) Temperature is maximum when $t \to \infty$ and

$$T_{\max} = T_0 + \frac{qd}{KA}$$

or, At maximum temperature,

rate of heat supplied by heater = rate of heat lost by gas

$$\Rightarrow \quad q = \frac{KA}{d}(T_{\max} - T_0) \quad \Rightarrow \quad T_{\max} = T_0 + \frac{qd}{KA}.$$

$\because$ Process is isobaric, $\dfrac{V_0}{T_0} = \dfrac{V_{\max}}{T_{\max}}$

$$\Rightarrow \quad V_{\max} = V_0\left(1 + \frac{qd}{KAT_0}\right).$$

---

6. An electron in a H atom at rest makes a transition from $n = 2$ energy state to $n = 1$ state. Assuming that the recoil energy of H-atom is small, calculate the fraction of energy difference between $n = 2$ and $n = 1$ level that goes into atomic recoil energy. [$mc^2 = 939$ MeV, where m is the mass of H-atom].

Soln.: From conservation of momentum, the total momentum before and after photon emission shall be zero.

$\therefore \quad mV = \dfrac{E}{pc}$ ... (i) [E = energy of photon]

But $E = E_2 - E_1 = 10.2$ eV.

Note that recoil kinetic energy of H-atom is very small due to its large mass and hence the entire energy may be assumed to be possessed by the photon.

$\therefore$ From (i), $mv = \dfrac{10.2 \text{ eV}}{c}$

Recoil of kinetic energy of H is

$$K = \frac{1}{2}mv^2 = \frac{(mv)^2}{2m} = 0.5\frac{(10.2)^2}{mc^2}$$

$$\Rightarrow \quad K = \frac{(0.5)(10.2)^2}{939 \times 10^6} = 5.54 \times 10^{-8} \text{ eV}.$$

Required fraction $= \dfrac{K}{E} = \dfrac{5.54 \times 10^{-3}}{10.2} = 5.43 \times 10^{-9}$.

Note : This fraction is too small. Hence we made almost no error in assuming that almost all energy is possessed by photon.

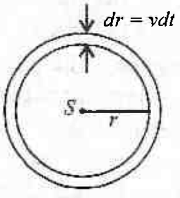
---

7. A radioactive source emits β-particles with kinetic energy K and has half life T. At an instant the concentration of β particles at a distance r from the source is C.

(a) Calculate the number of nuclei in the nuclide at that instant.

(b) If a small plate is placed at a distance r_0 from the source such that β particles strike normally and come to rest, calculate the pressure experienced by the plate. Mass of β particle is m.

Soln.: **(a)** Let A = activity of source.



The number of particles (β) emitted per second = A.

Consider an imaginary shell of radius r centred at the source. In a time interval dt, Adt number of β-particles cross the surface of the shell. If v be the speed of β particles, then Adt particles will be present inside the annular region of thickness $dr = vdt$.

Volume of annular space = $4\pi r^2\, vdt$

Concentration of β particles in this region (*i.e.* at a distance r) is

$$C = \frac{Adt}{4\pi r^2 vdt} \quad \Rightarrow \quad A = 4\pi r^2 vC$$

But $A = \lambda N$, where N is instantaneous number of radionuclide in the source.

$$\Rightarrow \quad N = \frac{A}{\lambda} = \frac{4\pi r^2 vC}{\lambda} = \frac{4\pi r^2 vCT}{\ln 2} \qquad \left[\because \lambda = \frac{\ln 2}{T}\right]$$

Also, $K = \dfrac{1}{2}mv^2 \quad \Rightarrow \quad v = \sqrt{\dfrac{2k}{m}}$

$$\therefore \quad N = \frac{4\pi r^2 CT}{\ln 2}\sqrt{\frac{2K}{m}}.$$

(b) Each β-particle strikes with a momentum mv and loses all its momentum.

$\therefore$ Change in momentum of each β particle = mv

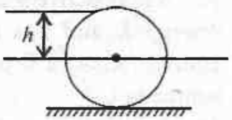
Pressure on plate = (mv) × number of particles striking per second per unit area

$$= mv \times \frac{A}{4\pi r_0^2} = mv \times \frac{\lambda N}{4\pi r_0^2}$$

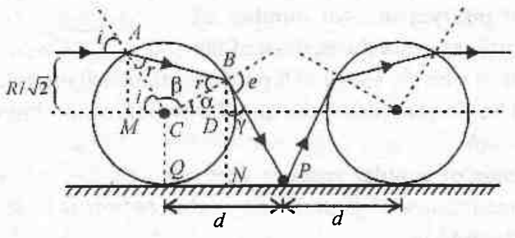
$$=\frac{mv\lambda}{4\pi r_0^2}\cdot\frac{4\pi r_0^2 CT}{\ln 2}\sqrt{\frac{2K}{m}} = mvC\sqrt{\frac{2K}{m}}$$

$$=\sqrt{2mK}\,C\sqrt{\frac{2K}{m}} = 2KC.$$

8. A cylindrical glass rod of radius R and refractive index $\sqrt{2}$ lies on a horizontal plane mirror. A ray of light is incident on the rod horizontally at a height h above the horizontal diameter of the rod such that $h = R/\sqrt{2}$ as shown in figure. At what distance a second similar rod, parallel to the first, be placed on the mirror, such that the emergent ray from the second rod is in the line with the incident on the first rod? (Take $\sqrt{3} = 1.75$, $\sin 15° = 1/4$, $\cos 15° = 9/10$.)



Soln.: The path of the ray is shown in figure. From symmetry of the problem, the distance between the rod will be $2d$.



From ΔAMC the angle of incidence will be

$$\sin i = \frac{R/\sqrt{2}}{R} = \frac{1}{\sqrt{2}} \Rightarrow i = 45°.$$

Using Snell's law at point A :

$$\sin 45° = \sqrt{2}\sin r \Rightarrow r = 30°$$

So from ΔACB, $\beta = 120° \Rightarrow \alpha = 15°$

Since here $\alpha \neq 0$ so CD will not be radius (note this step carefully).

$\Rightarrow BN > R$

Now, $d = QN + NP = CD + NP$

$= R\cos\alpha + BN\tan\gamma = R\cos\alpha + (BD + R)\tan\gamma$

$d = R\cos\alpha + (R\sin\alpha + R)\tan\gamma$ ... (i)

Since, $\sin i = \sqrt{2}\sin r = \sin e$

$\Rightarrow i = e = 45° \Rightarrow \gamma = 60°$

So, $d = R\cos 15 + (R\sin 15 + R)\tan 60$

$= 3.08R$

So required distance $= 2d = 6.18R$. ■

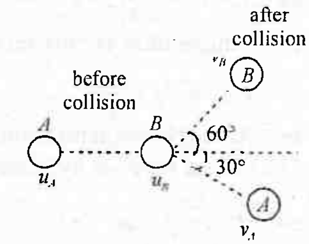
Contd. from page no. 4

Conservation of momentum

A ball at rest has no momentum. It is in its state of inertia. According to the law of conservation of momentum, the vector sum of the momentum is constant. That applies to closed systems.

When ball A is going to the right along the X axis it has momentum only in that direction. For our purposes let's say that the momentum of ball A is 5 m/s. Ball B is in the path of ball A. Ball A hits ball B and they move off in their respective angles. Momentum is represented by (mass × velocity). If ball A has a mass of 2 kg the momentum is equal to 10 kg m/s.

Ball B also has a mass of 2 kg. Dependent on the angle of ball A are the angles at which both balls will roll. Let's assume that ball A will go off at 30 degrees and ball B will go off at 60 degrees. After they come in contact with one another both balls will have a y and a x component. These components can be figured out with geometry.



By solving equations

$$m_B u_{Bx} + m_A u_{Ax} = m_A v_{Ax} + m_B v_{Bx}$$
$$m_B u_{By} + m_A u_{By} = m_A v_{Ay} + m_B v_{By}$$

We can easily calculate the velocities of ball A and B after coming in contact.

Collision

The key to billiards is to know what is going to happen to the balls after the collisions. This is important not only for making shots and pocketing balls, but also for setting up your next shot by placing the cue ball in line for the next ball. There are always ways of altering the spin of the ball to change where the ball will end up in. In a head on collision, the object ball will continue on the path that the cue ball was on before the collision took place. In angular, two dimensional collisions, the two balls will always have a resulting angle of 90 degrees. A collision is also takes place when you strike the ball with the cue stick. This is called an impluse.

The collisions in a game of pool can get very, very complex. For example, when you break, many of the balls are already moving at different speeds and different angles. These are difficult collisions to figure out vectors are needed to sort out that. The velocity of the ball can be determined by using vectors. The formula for this

SOLVED PAPER

BIHAR CECE'05 (MAINS)

1. A bullet of mass 10 g is fired horizontally into a wooden block of mass 10 kg, which lies on a smooth horizontal table. The bullet is embedded in the block and the block slides with a velocity 0.2 m/s after the impact. Find the muzzle velocity of the bullet fired from the gun and the total mechanical energy lost in the impact.

2. Two trains A and B are travelling in opposite directions along straight parallel lines at the same speed 60 km/h. A light aeroplane crosses above them. A person on the train A sees it cross at right angles, while a person on train B sees it cross at an angle $\tan^{-1}(1/2)$. At what angles does the aeroplane cross the line as seen from the ground? Also calculate the ground speed of the aeroplane.

3. A mass M moves in a vertical circle at the end of a string of length L. Its velocity at the lowest point is v_0. Determine the tension in the string when it makes an angle θ to the downward vertical.

4. A pendulum consists of a uniform rod AB of length $L = 0.5$ m and mass $M = 1$ kg. Calculate the period T of the pendulum, if it is suspended from a point C such that $AC = L/4$.

5. The effective gravity g_{eff} at a point of the earth's surface is defined by weighing an object and dividing it by its known mass. What is the ratio of the effective gravity between the earth's equator and the poles? (Assume the earth is a sphere of mass $M_e = 6 \times 10^{24}$ kg and radius $R_e = 6400$ km).

6. A cube of a material floats in a container of mercury. The coefficient of linear expansion of material is α and the coefficient of volume expansion of mercury is γ. As the temperature of the container is increased, find the relation between γ and α such that the cube does not go deeper in the container from its original position.

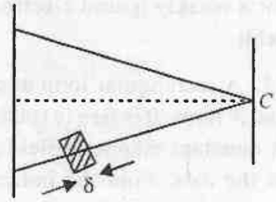
7. What is the radius of the smallest droplet that can form from water of surface tension 0.07 N/m and vapour pressure 2300 N/m^2?

8. A closed vessel 10 litres in volume contains air under a pressure of 10^5 N/m^2. What amount of heat should be imparted to the air to increase the pressure in the vessel five times?

9. A copper plate (thickness $d_1 = 9$ mm) and an iron plate ($d_2 = 3$ mm) are put together. The external surface of copper plate is maintained at a constant temperature of $T_1 = 50°C$ and that of the iron plate at $T_2 = 0°C$. Find the temperature T_x of the constant surface. The area of each plate is much greater than its thickness. Coefficient of thermal conductivity of copper and iron are 390 W/m. deg and 58.7 W/m deg respectively.

10. A long string of mass per unit length 0.2 kg/m is stretched to a tension of 500 N/ Find the speed of transverse waves on the string and the mean power required to maintain a travelling wave of amplitude 10 mm and wavelength 0.5 m.

11. A double slit experiment is shown in the figure. Each slit has width w. A thin piece of glass of thickness d, refractive index μ, is placed between one of the slits and the screen. The intensity at the central point is measured as a function of thickness δ. For what values of δ is the intensity at C a minimum?

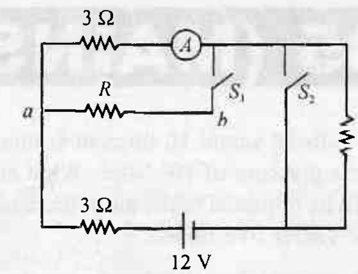


12. An optical doublet is formed from two lenses A and B made of glass of different refractive indices μ_A, μ_B respectively. Let A has two convex sides of radius of curvature R and lens B has one flat side and one concave side of radius of curvature R. What is the power of the doublet? For red, yellow and blue wavelengths, the refractive index μ_A is 1.50, 1.51 and 1.52 respectively whereas μ_B is 1.60, 1.62 and 1.64 respectively. What is the difference in power of the doublet for these three wavelengths?

13. Two masses each of $m = 1$ kg with equal charges Q are suspended by light strings of length $L = 1$ m

from a point. The strings hang at 30° to the vertical. Determine Q.

14. In the circuit, the ammeter reading is taken with both switches open as well as with both switches closed. The readings are the same in the two cases. Neglect the internal resistance of the battery. Determine the resistance R.



15. Determine the force between two circular loops of wire having the same radius R, and carrying the same currents I, when they are located at a distance L apart, with $L >> R$, and with their axes parallel and the currents in the same direction. Express the force in terms of the angle θ between their axes and their line of centres.

16. A classical electron moves in a circular orbit around a proton. Derive a differential equation for the electron energy, taking into account the classical radiation loss. On this basis, calculate the approximate time it takes for a weakly bound electron to fall into the first Bohr orbit.

17. A rectangular loop of conducting wire has area A and N turns. It is free to rotate about an axis of symmetry. A constant magnetic field B is present perpendicular to the axis. Find the induced e.m.f. as a function of time if the loop is rotated at angular velocity ω?

18. Use the Bohr model of hydrogen atom to show that when an electron jumps from the level n to level $n - 1$, the frequency of the emitted photon is close to the electron rotation frequency (in Hz) if n is very large.

19. Calculate the speed and the de-Broglie wavelength of an oxygen molecule at room temperature.

20. The current gain of a transistor in a common emitter circuit is 49. Calculate its common base current gain. Find the base current when the emitter current is 3 mA?

SOLUTIONS

1. $m = 0.10$ kg, $M = 10$ kg, $u = ?$, $V = 0.2$ m/s

Applying the law of conservation of momentum,

$0.10 \times u = 10.10 \times 0.2 \Rightarrow u - 20.2$ m/s.

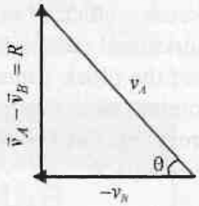
The muzzle velocity of the bullet = 20.2 m/s

Total mechanical energy lost $= \frac{1}{2}mu^2 - \frac{1}{2}(M+m)V^2$

$\Rightarrow$ Loss of energy $= \frac{1}{2}\times 0.10 \times 20.2^2 - \frac{1}{2}\times 10.10 \times 0.2^2$

$= 40.2$ Joules.

2. Train moves at 60 km/hr to the east.



The relative velocity of the plane with respect to A

$$(\vec{v}_A - \vec{v}_B)^2$$
$$= v_A^2 + v_B^2 - 2\, v_A v_B \cos\theta$$

as the plane makes an angle θ (θ is to be determined).

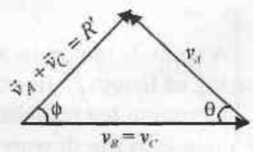
Given $(\vec{v}_A - \vec{v}_B)$ is $\perp$ to $\vec{v}_B$

$\therefore$ By the law of the triangle (Pythagores theorem), hypotenuse, $v_A^2 - v_B^2 = R^2$

$\therefore\ v_A^2 - v_B^2 = v_A^2 + v_B^2 - 2v_A v_B\cos\theta$

$\Rightarrow 2v_B^2 = 2v_A v_B\cos\theta \Rightarrow v_B = v_A\cos\theta.$

For the train C moving with the same velocity,



$$R' = \vec{v}_A + \vec{v}_C = v_A + v_B$$
$$= v_A^2 + v_B^2 + 2v_A v_B\cos\theta$$

R' makes an angle ϕ such that

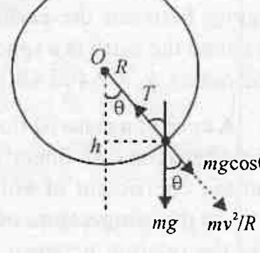
$$\tan\phi = \frac{1}{2} = \frac{v_A\sin\theta}{v_B + v_A\cos\theta}$$

$\Rightarrow v_B + v_A\cos\theta = 2v_A\sin\theta$

But $v_A = \dfrac{v_B}{\cos\theta} \Rightarrow v_B + \dfrac{v_B}{\cos\theta}\cdot\cos\theta = 2\dfrac{v_B}{\cos\theta}\sin\theta$

$\Rightarrow 2v_B\tan\theta = 2v_B \Rightarrow \tan\theta = 1.\ \therefore\ \theta = 45°.$

3. The tension of the string $T = \dfrac{mv^2}{R} + mg\cos\theta$



But by the law of conservation of mechanical energy,

$$\frac{1}{2}mv_0^2 = \frac{1}{2}mv^2 + mgh$$

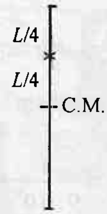
$\therefore\ v^2 = v_0^2 - 2gh$

$\Rightarrow v^2 = v_0^2 - 2gR(1 - \cos\theta)$

$\therefore\ T = \dfrac{m}{R}\{v_0^2 - 2gR(1-\cos\theta)\} + mg\cos\theta.$

The tension = the component of the weight of m + the centrifugal force mv^2/R.

4. Moment of inertia of the rod about the centre of mass $= m \cdot \frac{l^2}{12}$.



$\therefore$ About the axis of rotation O,

$I = I_{C.M.} + md^2$

$$= m\left\{\frac{l^2}{12} + \frac{l^2}{16}\right\} = \frac{7ml^2}{48}.$$

This is a physical pendulum.

The period of oscillation, $T = 2\pi\sqrt{\frac{I}{ml'g}}$

where I is the moment of inertia and l' is the distance of the centre of mass from the axis of rotation.

$$\therefore \quad T = 2\pi\sqrt{\frac{7m}{48}\frac{l^2}{m(l/4)g}}$$

$$T = 2\pi\sqrt{\frac{7}{12}\frac{l}{g}} = \pi\sqrt{\frac{7}{3}\frac{l}{g}}.$$

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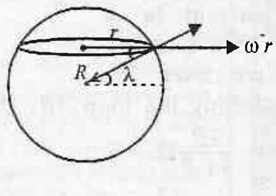
5. $g' = g - \omega^2 r\cos\lambda$



But $r = R\cos\lambda$

$\therefore \quad g' = g - \omega^2 R\cos^2\lambda$

At the equator, it is

$$g = \left|\frac{GM}{R^2}\right| - \omega^2 R$$

At the pole, $\lambda = 90°$, $\frac{GM}{R^2}\cos\lambda = 90°$

$G = 6.67 \times 10^{-11}$, $M = 6 \times 10^{24}$,

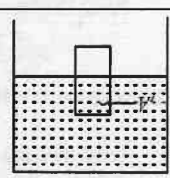
$R = 6400$ km $= 6.4 \times 10^3$ m.

$\omega = \frac{2\pi}{24 \times 60 \times 60}$, the angle turned through/s.

One can substitute and get the values.

---

6. If V' is originally immersed in mercury, V_0 the total volume of the body, ρ, the density of the material



$V'\rho_{Hg}\, g = V_0\rho \times g$

$V'(1 + 3\alpha\Delta\theta)\, \rho_{Hg}(1 - \gamma\Delta\theta)g$

$= V_0(1 + 3\alpha\Delta\theta)\, \rho(1 - 3\alpha\Delta\theta) \times g$

But $V'\rho_{Hg}\, g = V_0\rho g$. If $(1 - \gamma\Delta\theta) = (1 - 3\alpha\Delta\theta)$

i.e. if $\gamma = 3\alpha$, the body will not rise or fall with respect to the surface of mercury.

---

7. Excess of pressure $= \frac{2T}{R}$ as this is a droplet (with one surface)

$$2300 \text{ N/m}^2 = \frac{2 \times 0.07}{R} \text{ N/m}$$

$$\Rightarrow \quad R = \frac{2 \times 0.07}{2300} \text{ m} = 6.086 \times 10^{-5} \text{ m}$$

$= 6 \times 10^{-2}$ mm $= 0.06$ mm.

8. $PV = nRT$. At constant V, $P \propto T$

Therefore, the rise of temperature is 5 times if pressure is to be increased 5 times.

The volume of air enclosed = 10 litres at 10^5 N/m²

At NTP, *i.e.* temperature 273°K, $P \approx 1 \times 10^5$ N/m², volume of air = 22.4 litres.

$\therefore$ Number of moles of air $= \frac{10}{22.4}$

$\Delta\theta = (5 \times 273 - 273)$ K $= 1092$ K.

$\therefore$ Heat required $= \frac{10}{22.4} \times \frac{5}{2}R \times 1092$ K

$= 1218.75R$ Joules $= 1218.75 \times 8.31 = 10128$ J.

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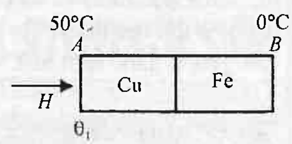
9. K of copper = 390 W/m deg;

K for iron = 58.7 W/m deg.

In series, potential difference across Cu + potential difference across iron = potential difference across AB



Potential difference here is the temperature difference, dQ/dt is the same. (dQ/dt = heat transferred/unit time for heat transfer and the charge conducted per second for current transfer)

$$\frac{dQ}{dt} = \frac{(50-0)}{(L_1/K_1A)+(L_2/k_2A)} \Rightarrow A = 50$$

$$\frac{L_1}{K_1} = \frac{9\times10^{-3}\text{ m}}{390};\ \frac{L_2}{K_2} = \frac{3\times10^{-3}}{58.7}$$

$$\frac{L_1}{K_1} + \frac{L_2}{K_2} = 0.074\times10^{-3}$$

$$\therefore \quad \frac{dQ}{dt} = \frac{50}{0.074\times10^{-3}} = 674\times10^3 \text{ cal/s. per unit area}$$

$$\therefore \quad 674\times10^3 = \frac{50-\theta}{\frac{9\times10^{-3}}{390}} \Rightarrow \theta = 34.5°\text{C}$$

(one can check with Fe also).

---

10. Velocity of a transverse wave in a string $= \sqrt{\frac{T}{\mu}}$

where T is the tension and μ = mass per unit length. $T = 500$ N, $\mu = 0.2$ kg/m.

$\therefore$ v, the speed of the wave $= \sqrt{\frac{500}{0.2}} = 50$ m/s.

Mean power, $P=\frac{1}{2}\rho v\omega^2 A^2\cdot S$ where S is the area of cross-section.

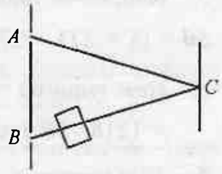
$\therefore\quad \rho\cdot S=\mu \qquad P=\frac{1}{2}\times\mu\times v\times\frac{4\pi^2\cdot v^2}{\lambda^2}A^2$

Given, the amplitude A = 10 × 10^{-3} m, λ = 0.5 m

$\therefore\quad P=\frac{1}{2}\times 0.2\times 50\times\frac{4\pi^2\times 2500}{0.5^2}\times(10\times10^{-3})^2$

= 197 watts.

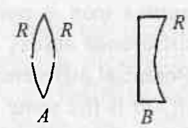
11. At C, if there is no plate, one gets maximum intensity because the path difference is zero.



If the path difference is $\lambda/2$, then one gets minimum. If a plate of thickness t is inserted, the equivalent path is $BC - t + \mu t$ *i.e.* $BC - t(1-\mu)$.

If t or d the the thickness is such that $t(1-\mu)=\lambda/2$, one gets a dark spot at C.

12. $\frac{1}{f_A}=(\mu_A-1)\left(\frac{1}{R_1}+\frac{1}{R}\right)$



$=(\mu_A-1)\frac{2}{R}$

$\frac{1}{f_B}=(\mu_B-1)\left(0-\frac{1}{R}\right)=-\frac{(\mu_B-1)}{R}$

Therefore the power of the double lens

$=\frac{1}{f_A}+\frac{1}{f_B}=(\mu_A-1)\frac{2}{R}-\frac{(\mu_B-1)}{R}$.

Red : μ_A = 1.50, μ_B = 1.60

$(\mu_A-1)\frac{2}{R}-(\mu_B-1)\frac{1}{R}=\frac{1.00}{R}-\frac{0.60}{R}=\frac{0.40}{R}$

Yellow : μ_A = 1.51, μ_B = 1.62

$\therefore\quad 0.51\times\frac{2}{R}-\frac{0.62}{R}=\frac{0.40}{R}$

Blue : μ_A = 1.52, μ_B = 1.64

$\therefore\quad 0.52\times\frac{2}{R}-\frac{0.64}{R}=\frac{0.40}{R}$

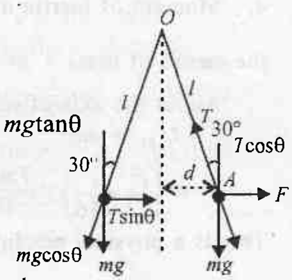
The powers of the combination are the same for all the three colours.

13. $T\cos\theta = mg$

$\Rightarrow\quad T=\frac{mg}{\cos\theta}$

$T\sin\theta=\frac{1}{4\pi\varepsilon_0}\cdot\frac{q^2}{(2d)^2}$

$\Rightarrow\quad mg\tan\theta=\frac{1}{4\pi\varepsilon_0}\frac{q^2}{4d^2}$



$d = l\sin30°$

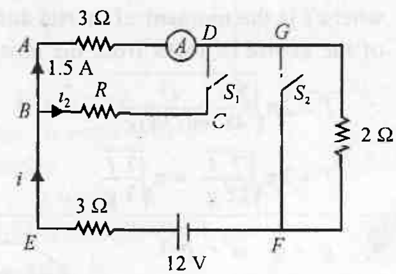
$\therefore\quad q^2 = 4\pi\varepsilon_0 \times 4 \times l^2\sin^2\theta\ mg\tan\theta$

$=\frac{1}{9\times10^9}4\times\frac{1}{4}\times 1\times10\times\frac{1}{\sqrt{3}}$

$q^2=\frac{10^{-8}}{9\sqrt{3}}$

q = 0.25 × 10^{-4} = 25 μC each.

14. When S_1 and S_2 are open, the total resistance in the circuit is 8 Ω.



$i=\frac{12}{8}=1.5\text{ A}$.

This is also the current in A when S_1 and S_2 are closed.

Taking the loop $ABCD$, the equivalent resistance is $\frac{3R}{3+R}\Omega$.

$\therefore\quad \frac{12}{3+\frac{3R}{3+R}}=i_2+1.5\text{ A}$

But in the loop $ABCD$, 3 × 1.5 = $R \times i_2$

$\therefore\quad \frac{12}{3+\frac{3R}{3+R}}=\frac{9}{2R}+\frac{3}{2}$

$\Rightarrow\quad \frac{12(3+R)}{9+6R}=\frac{9+3R}{2R}=\frac{3(3+R)}{2R}$

$=\frac{4}{9+6R}=\frac{1}{2R}\Rightarrow R=4.5\,\Omega$

One can verify that $\frac{3R}{3+R}=\frac{9}{5}\ \Omega$

$\therefore\quad$ Total resistance = $\frac{9}{5}+3=\frac{24}{5}\ \Omega$.

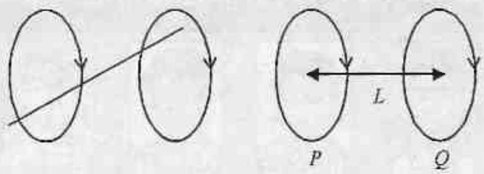
$\therefore\quad$ Current = $\frac{12\times5}{24}=2.5\text{ A}$.

$\therefore\quad$ Current i_2 = 1 A.

[4.5 × 1 = 3 × 1.5 in the loop $ABCD$ verified]

15. When two circular coils are carrying current in the same direction, they are equal to two magnetic dipoles having the north poles on the right hand side for both. They will be attracted because the N pole of P is facing the south pole of Q. When the distance is very large composed to the radius, the field due to P at a distance

L is



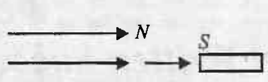
$$\vec{B} = \frac{\mu_0}{4\pi} \cdot i \cdot \frac{2\pi R^2}{(L^2+R^2)^{3/2}} = \frac{\mu_0}{4\pi} \frac{i\, 2\pi R^2}{L^3} \qquad ...(L >> R)$$

As the magnetic moment of coil $Q = i\,\pi R^2$.

$\therefore$ the force of attraction = $BM\cos\theta$, as $\cos\theta = 1$ here,

Force of attraction $= \frac{\mu_0}{4\pi} \cdot i \cdot \frac{2 \cdot (\pi R^2)}{L^3} \cdot i\pi R^2$

$= \frac{\mu_0}{4\pi} \cdot \frac{i^2 \cdot 2 \cdot (\pi R^2)^2}{L^3}$



$= \frac{\mu_0}{2\pi} \cdot i^2 \cdot \frac{S^2}{L^2}$ where S - area of each coil.

If the axes are making an angle Q. Then is $BM\cos\theta$.

16. As a varying electric and magnetic field alone can give a wave, an electron which is at rest or moving with a constant velocity will not be able to emit radiation. An accelerated electron radiates energy according to Maxwell's theory.

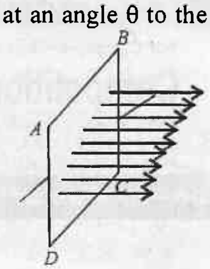
The energy emitted by an electron per second is

$F \cdot ds = qEV$

Energy emitted by a wave $\frac{1}{2}\varepsilon_0 c E_0{}^2$ per second/unit area.

If an electron moving in a circular orbit round the proton has an acceleration towards the centre due to centripetal force, a force is acting on the electron causing acceleration will cause radiation energy loss. As energy is continuously lost while making rotation. There is no equality of the centripetal force of attraction and the decreasing centrifugal force of $m\omega^2 r$. The attraction towards the nucleus, the centripetal force goes on increasing and till some angular momentum is left, it will continue to turn but coming nearer and nearer the nucleus and finally it falls on the nucleus.

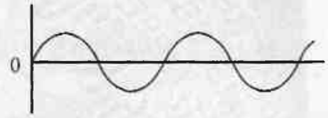
17. Let the normal to the loop be at an angle θ to the magnetic field. The flux through the coil = $BAN\cos\theta$ where B is the magnetic induction, A is the area of loop and N = number of turns of the coil. *i.e.* $\phi = BAN\cos\omega t$.



$\therefore$ E_{induced} =

$-\frac{d\phi}{dt} = +BAN\omega\sin\omega t$

When $\theta = 90°$, *i.e.* $\omega t = 90°$, the value is maximum.



The coil is at that instant in the plane of the field.

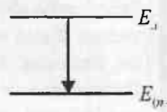
$E_0 = BAN\omega$

When it is perpendicular, ϕ is maximum, $d\phi/dt = 0$.

$E = E_0\sin\omega t$, where $E_0 = BAN\omega$.

18. According to Bohr's correspondence principle, for large quantum numbers, the classical result will be the same as those given by the quantum theory.

$h\upsilon = E_n - E_{n-1}$



$$\Rightarrow \upsilon = \frac{2\pi^2 mk^2e^4}{h^3}\left\{\frac{1}{(n-1)^2} - \frac{1}{n^2}\right\}$$

$$\Rightarrow \upsilon = \frac{2\pi^2 mk^2e^4}{h^3} \cdot \frac{2}{n^3} \quad [\text{if } n \simeq (n-1) \text{ and } 2n >> 1]$$

As $\frac{n^2-(n-1)^2}{n^2(n-1)^2} \simeq \frac{2n}{n^4}$; $\Rightarrow \upsilon = \frac{4\pi^2 mk^2e^4}{h^3 n^3}$

$\frac{v}{2\pi r} = \upsilon$, the classical orbital frequency.

$$v = \frac{2\pi ke^2}{nh};\ r = \frac{n^2h^2}{4\pi^2 mke^2}$$

$$\therefore \frac{v}{2\pi r} = \frac{2\pi ke^2}{nh} \cdot \frac{1}{2\pi} \frac{4\pi^2 mke^2}{n^2h^2} = \frac{4\pi^2 mk^2e^4}{h^3n^3}.$$

19. The average velocity of an oxygen molecule at room temperature is

$$v_{\text{r.m.s}} = \sqrt{\frac{3kT}{M}} = \sqrt{\frac{3 \times 1.38 \times 10^{-23}}{32 \times 1.66 \times 10^{-27}}} = 4.8 \times 10^2 \text{ m/s}$$

$$\therefore \lambda_{\text{de Broglie}} = \frac{h}{mv} = \frac{6.6 \times 10^{-34}}{32 \times 1.66 \times 10^{-27} \times 4.8 \times 10^2}$$

$= 0.25 \times 10^{-10}$ m = 0.25 Å.

20. Current gain of the common emitter circuit

$$= \frac{I_C}{I_B} = 49 = \beta$$

But $I_C + I_B = I_E$; $\therefore \frac{\beta}{\beta+1} = \frac{I_C \cdot I_B}{I_B(I_C+I_B)} = \frac{I_C}{I_E} = \alpha$

$\therefore \frac{I_C}{I_E}$ = common base gain, $\alpha = \frac{\beta}{\beta+1} = \frac{49}{50}$

But $I_C = \frac{49}{50} \cdot I_E = \frac{49}{50} \times 3 \text{ mA} = 2.94$ mA

$\therefore I_B = 3 - 2.94$ mA = 0.06 mA.

SOLVED PROBLEMS

Practice Question for PMT

1. If $x = a^n b^m c^p$, $y = \frac{a^n b^m}{c^p}$, $z = \frac{a^n}{b^m e^p}$.
   (a) The error in the in the determination of x = that in y > error in z
   (b) The error in z > error in y > error in x
   (c) Error in x = error in y > error in z.
   (d) None.

2. Mark the wrong statement/statements.
   (a) For the same quantities such as potential or kinetic energy of a mass, the dimensions are the same
   (b) If the dimensions are the same, they denote the same physical quantity
   (c) The dimensions of the same quantity need not be the same
   (d) None.

3. If the initial velocity is zero and the acceleration of a body is 3 t, the distance travelled in 5 seconds is given by
   (a) 187.5 m (b) 62.5 m
   (c) 125 m (d) None.

4. When a body is falling down freely from a height, the relation between distance and time is given by
   (a) straight line with increasing time
   (b) It has the shape of a circle
   (c) It is a parabola with decreasing curve and then remains constant
   (d) It is a parabola with increasing curve and then remains constant.

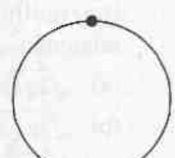
5. A projectile is fired on a horizontal ground at an angle of 45° with an initial velocity of $40\sqrt{2}$ m/s.
   (a) The horizontal distance travelled by the projectite in 1s is half of that travelled in 2s and the horizontal distance travelled in 6s is half of that travelled in 12s.
   (b) The horizontal distance travelled in 6s is less than the distance travelled in 4s
   (c) The horizontal distance travelled in 8 s = the horizontal distance travelled in 16 s
   (d) None.

6. When a body is falling freely from a height, its maximum potential energy = its maximum kinetic energy.
   When a satellite is turning round the earth in an orbit of radius r, the magnitude of
   (a) The potential energy of the satellite = kinetic energy of the satellite
   (b) The potential is double the kinetic energy
   (c) The kinetic energy is double the potential energy
   (d) None.

7. A man is travelling horizontally at 3 m/s to the east and the rain drops are falling vertically at 4 m/s. At what angle should he hold the umbrella ?
   (a) At an angle θ to the vertical in the north-west direction where $\theta = \sin^{-1}\frac{3}{5}$
   (b) Vertically
   (c) At θ to the vertical where $\theta = \sin^{-1}\frac{3}{5}$ in the north-east direction
   (d) At an angle $\theta = \sin^{-1}\frac{4}{5}$ to the vertical

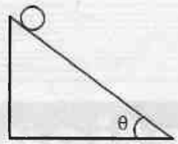
8. Two vectors $\vec{A}$ and $\vec{B}$ are given by $\vec{A} = (2\hat{i} - 3\hat{j} + 2\hat{k})$ and $\vec{B} = (4\hat{i} - 6\hat{j} + 4\hat{k})$, the angle between $\vec{A}$ and $\vec{B}$ is given by
   (a) 90° (b) 45°
   (c) 0° (d) None.

9. When a particle of mass m is making a vertical rotation with an angular velocity ω, at the maximum height, if the tension is T, then



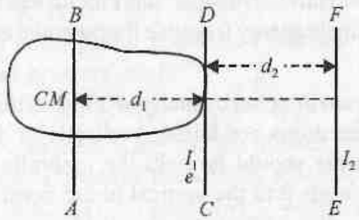
   (a) $T = mg + m\omega^2 r$ because mg is acting dounwards, the centripetal force is $m\omega^2 r$
   (b) $T = mg - m\omega^2 r$ as $m\omega^2 r$ is the centrifugal force
   (c) $T = mg$ as T is the centripetal force
   (d) $T = m\omega^2 r - mg$ as $m\omega^2 R$ is acting outward (centrifugal force) and $T + mg$ is acting towards the centre

10. If two spherical shells A and B of masses 2 kg and 5 kg and radii 0.1m and 0.3 m respectively, roll down the inclined plane starting from rest,



(a) The heavier mass will roll down the inclined plane faster and has an acceleration $g \sin\theta$
(b) The lighter one will roll faster with an acceleration $g \sin\theta$
(c) Both will reach the end with the same velocity and their accelerations will be more than $g \sin\theta$
(d) Both will reach at the same time and their acceleration will be less than $g \sin\theta$.

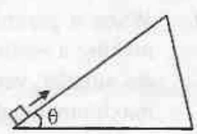
11.



Moment of inertia about EF, I_2
(a) $I_1 + Md_2^2$
(b) I_1 as EF is outside the body
(c) $I_2 = I_1 + Md_2^2$
(d) $I_2 = I_1 + Md_2^2 + 2Md_1d_2$

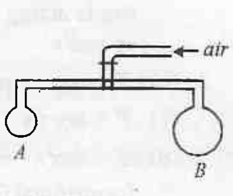
12. The work done by a body of mass m moving with uniform acceleration a towards the centre, in rotating through π degrees is
(a) $ma\pi r$ (b) zero
(c) $ma \cdot 2r$ (d) None.

13. A block is projected up an inclined plane with a velocity v. If there is friction between the block and the inclined plane, the minimum velocity v is



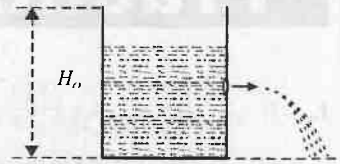
(a) $\sqrt{2g\sin\theta h}$
(b) $\sqrt{2\mu_k gh\cot\theta}$
(c) $\sqrt{2\mu_k gh\cot\theta + 2gh}$
(d) $\sqrt{2gh - 2\mu_k gh\cot\theta}$

14. A and B are soap bubbles formed by filling air. If the radius of A is smaller than B, if these two bubbles are now connected to each other,



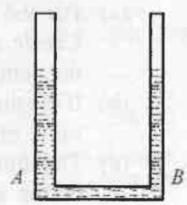
(a) air flows from B to A
(b) air flows from A to B
(c) there is steady condition. No air will flow from A to B or B to A
(d) None.

15. The position of the hole for getting the maximum range of efflux



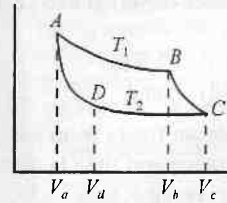
(a) should be at the bottom
(b) at $H_0/2$ (c) at the top
(d) the range attained will only depend on the total quantity of water in the tank and not the position of the hole.

16. If a manometer is made of two narrow tubes A and B of radii r_1 and r_2 and T is the surface tension of a liquid of density 10^3 kg/m^3, the liquid level in A will be



(a) equal to B
(b) lower than B
(c) higher than B (d) cannot say.

17.



AD, BC are adiabatics. The ratio of volumes
(a) $\frac{v_a}{v_d} > \frac{v_b}{v_c}$ (b) $\frac{v_a}{v_d} = \frac{v_b}{v_c}$
(c) $\frac{v_a}{v_d} < \frac{v_b}{v_c}$ (d) None.

18. The electric field due to a semicircular ring of charges at the centre is
$E = \frac{\lambda \times 2}{4\pi\varepsilon_0 \pi}$
Therefore the electric field at the centre of a circular ring is
(a) $\frac{4\lambda}{4\pi\varepsilon_0 r}$ (b) $\frac{2\lambda}{4\pi\varepsilon_0 r}$
(c) zero (d) None.

19. The magnetic field at the centre of a semicircular

wire of radius a carrying current is $\frac{\mu_0 i}{4a}$. The magnetic field at the centre of the coil is

(a) $\frac{\mu_0 i}{2a}$ (b) zero

(c) $\frac{\mu_0 i}{4\pi\varepsilon_0}\frac{1}{r^2}$ (d) None.

20. Two metal spheres A and B of radius 5 cms and 20 cms are kept at a large distance and connected by a long wire. It the charges on A and B are $5\mu e^+$ and $10\mu e^+$, charges flow

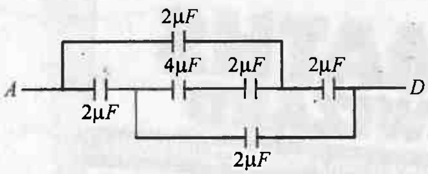
(a) from A to B

(b) from higher to lower charges because B is having a higher charge

(c) from lower charge to higher charge

(d) from a charge having a higher potential energy to the one having lower potential energy.

21.

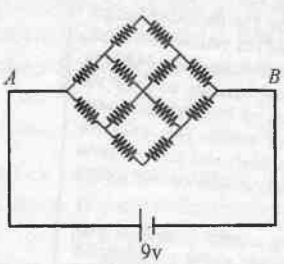


The total capacitance is

(a) $4\mu F$ (b) $2\mu F$

(c) $1\mu F$ (d) $0.5\mu F$

22.



All resistances have equal values, 1Ω each. The current in the circuit is

(a) 6 A (b) 9 A

(c) 4 A (d) 3 A

23. The difference between the electrical field lines due to a charge and those due to a magnet are

(a) The magnetic fied lines start from a north pole and end in south poles. The lines are closed

(b) The magnetic field lines start from a south pole and end in north pole

(c) Magnets are always dipoles, electric charges can exist as isolated charges

(d) Electric dipoles exist but magnets are monopoles

24. The ratio of the magnetic moment to the angular momentum of an electron orbiting in the hydrogen atom according to classical physics, is given by

(a) $\frac{e}{m}$ (b) $\frac{e}{2m}$

(c) $\frac{e}{mc}$ (d) None.

25. Bohr's assumption that the angular momentum of the electron in H atom is $n\hbar$

(a) quantisation of energy

(b) quantisation of the de Broglie wave similar to waves on a sonometer wire of open tube

(c) similar to waves in a closed tube

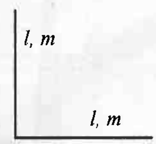
(d) quantisation of compton wave length.

26. Find the relation between torque and

(i) angular accelration and

(ii) angular momentum

27. Two rods of length l and mass m are in L shape. Find the moment of inertia about an axis passing through the point of joining and perpendicular to the plane of L-section

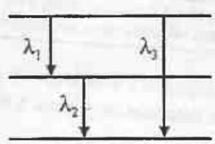


28. How does resistance vary in semiconductors with temperature.

(a) increases (b) decreases

(c) no rlation etc.

29. Find the relation between λ_1, λ_2 and λ_3

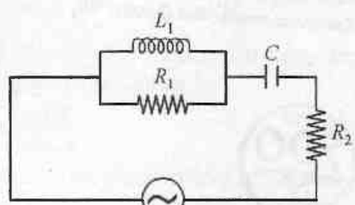


(a) $\lambda_3 = \lambda_1 + \lambda_2$

(b) $\frac{1}{\lambda_1} + \frac{1}{\lambda_2} = \frac{1}{\lambda_3}$

(c) none.

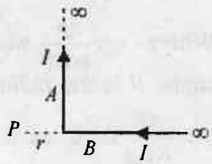
30.



(a) find the phase difference between the currents in L, and R_1

(b) and the phase difference between the potential differences across C and R_2

31. If two conductors of infinite lengh carry the same current in the same direction. What is the magnetic field at P due to A and B



32. If the kinetic energy of photons produced from a metal by irradiating the metal with 4000 A° radiation was 1.6 eV, the kinetic energy of photons produced by 6000 A° will be

(a) 2.4 eV (b) 1.6 eV
(c) 1.0 eV (d) 0.6 eV

33. The ground state energy of the electron in the hydrogen atom is – 13.6 eV
The ionization energy of H atom is
(a) – 13.6 eV (b) 13.6 eV
(c) depends on the number of the orbit
(d) $\frac{-13.6\text{eV}}{2}$

34. What is the maximum wavelength that can be detected by a semiconductor photo detector if the band gap of the semiconductor
Eg = 0.75 eV ? (given hc = 12400 eV A°)
(a) 165.3 (b) 1653 A°
(c) 16530 A° (d) 165.3 nm

35. In an X-ray tube (copper target), if the excitation energy of the K level is 9.5 KeV, is it possible to have X-rays and if so what is the wave length, if one applies a potential of 8 KeV ?

SOLUTIONS

1. (d) : $x = a^n b^m c^p$
$\ln x = n\ln a + m\ln b + p\ln c$ differentiating,

$$\frac{dx}{x} = n\frac{da}{a} + m\frac{db}{b} + p\frac{dc}{c}$$

$$\Rightarrow \text{Error \%} = \frac{dx}{x} = \left|n\frac{da}{a}\right| + \left|m\frac{db}{b}\right| + \left|p\frac{dc}{c}\right|$$

$$\frac{dy}{y} = \left|n\frac{da}{a}\right| + \left|m\frac{da}{b}\right| + \left|-p\frac{dc}{c}\right|$$

$$\frac{dz}{z} = \left|n\frac{da}{a}\right| + \left|-m\frac{db}{b}\right| + \left|-p\frac{dc}{c}\right|$$

Errors $\frac{dx}{x} = \frac{dy}{y} = \frac{dz}{z}$.

2. (b) : (a) mgh and $\frac{1}{2}mv^2$ have the same dimensions. True.

(b) Torque and work done have the same dimensions
$\tau = \bar{r} \times \bar{F}$; W = r. F.
But they are different quantities statement is false.
(c) This is surprisingly true because if one takes work done, power or energy in mechanics, and the same thing in electricity, the current and charge have no analogue in mechanics. Their dimensions are different although both are in different forms of energy and one can be converted into the other

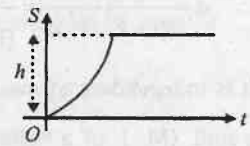
3. (b) : $a = \frac{dx}{dt} \Rightarrow dv = adt$

$\therefore\ v = \int 3t\,dt = \frac{3t^2}{2}$

$$v = \frac{ds}{dt} \Rightarrow ds = vdt \Rightarrow S = \int \frac{3}{2}t^2 dt = \frac{3}{2}\cdot\frac{t^3}{3} = \frac{t^3}{2} = \frac{125}{2} = 62.5\text{m}$$

4. (d) : $u = 0;\ s = \frac{1}{2}gt^2$

This is a parabola with increasing distance but it remains constant when it reaches the ground.



5. (c) : The time taken by the projectile to reach the maximum height (at which its final vertical component is zero) is given by,

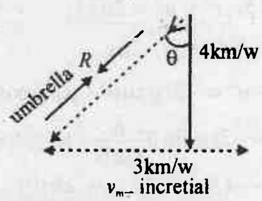
$$0 = 40\sqrt{2}\cdot\sin 45° - gt \Rightarrow 40 = 10 \times t \Rightarrow t = 4s$$

The time of flight is 8s. After 8 seconds, the projectile cannot travel as it has already hit the ground.

6. (b) : The magnitude of the potential energy $= \left|-\frac{GMm}{r}\right|$.

The kinetic energy of the satellite $= \frac{1}{2}\frac{GMm}{r}$.

7. (c) : The relative velocity of the rain with respect to the man = velocity of the rain w.r.t. the inertial frame – velocity of the man w.r.t. the inertial frame.



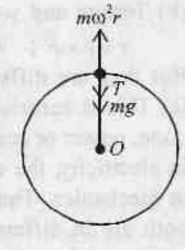
$\therefore\ \theta = \sin^{-1}\frac{3}{5}$ in the $N-E$ direction.

8. (c) : The two vectors are parallel. Therefore the angle between them is 0°.
$\bar{A}\cdot\bar{B} \neq 0$ but $\bar{A}\times\bar{B}$ will be zero.

$$\bar{A}\times\bar{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & -3 & 2 \\ 4 & -6 & 4 \end{vmatrix} = \hat{i}(0) - \hat{j}(0) + \hat{k}(0) = 0$$

$\bar{A}\cdot\bar{B} = 8 + 18 + 8 = +34$.

9. (d) : $T + mg = m\omega^2 r$

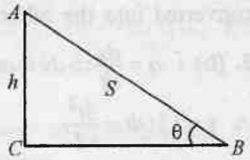


$\therefore \quad T = m\omega^2 r - mg$

$m\omega^2 r$ is the centrifugal force and $T + mg$ is the centripetal force acting towards the centre.

10. (d) : The K.E. of the rolling body at B.

P.E. at A.



$\Rightarrow mgh = \frac{1}{2}m(1+\frac{k^2}{r^2})v^2$

$\therefore \quad v^2 = \frac{2gh}{(1+k^2/r^2)}$

But $v^2 - a^2 = 2as$

$\therefore \quad a = \frac{gh}{(1+k^2/r^2)s} = \frac{g\sin\theta}{(1+\frac{2}{3}\frac{r^2}{r^2})} = \frac{3}{5}g\sin\theta$

It is independent of mass and the radius and less than $g\sin\theta$. (M. I. of a hollow sphere $= \frac{2}{3}mr^2$).

11. (d) : $I_1 = I_{c.m.} + M d_1^2$ where d is the distance of the centre of mass. $I_{c.m.} = I_1 - M d_1^2$.

$\therefore \quad I_2 = I_{c.m} + M(d_1 + d_2)^2$

$= I_1 - Md_1^2 + Md_1^2 + Md_2^2 + 2Md_1d_2$

$I_2 = I_1 + M d_2^2 + 2Md_1d_2$.

12. (b) : For rotation, the work done is Torque × θ. As the motion is of uniform angular velocity, there is no acceleration and therefore no torque. No work is done.

13. $v^2 - u^2 = 2as$; $\quad v = 0$

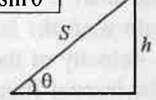
$$\boxed{\frac{h}{S} = \sin\theta \qquad S = \frac{h}{\sin\theta}}$$

$\therefore \quad -u^2 = -2as$

$-u^2 = -2(g\sin\theta + \mu_k g\cos\theta)S$

$= -2(g\sin\theta\frac{h}{\sin\theta} + \mu_k g\cos\theta\frac{h}{\sin\theta})$

$= -(2gh + 2\mu_k gh \cdot \cot\theta)$.



14. Excess of pressure inside the film $= \frac{4T}{R}$.

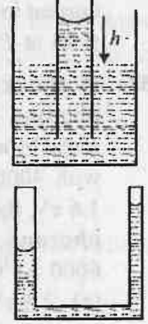
As $R_A < R_B$, Pr $A >$ Pr B.

$\therefore$ Air will flow from A to B.

But as B is already large, it will grow further reducing the pressure inside, till A collapses.

15. The range is maximum when $h = \frac{H_0}{2}$. At a height h below or above the height $\frac{H_0}{2}$, the range will be the same.

16. The excess pressure

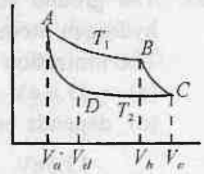


$h\rho g h = \frac{2T}{r} \Rightarrow hr$ is a constant.

Where $r = \frac{R}{\cos\theta}$ where θ is contact angle, R is the radius of the tube.

$h - \frac{2T}{R\rho g}\cos\theta$ as $h R$ is a constant, larger the radius, smaller the height of the miniscus therefore level on the left hand side will be less and on right hand side will be more.

17. (b) : The ratio of volumes



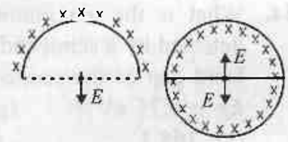
PV^{λ} = constant for adiabatic curves

$PV = \mu RT$

$\therefore \quad TV^{\gamma-1}$ = constant

$\frac{T_1V_a^{\gamma-1}}{T_2V_d^{\gamma-1}} = \frac{T_1V_b^{\gamma-1}}{T_2V_c^{\gamma-1}} \Rightarrow \frac{V_a}{V_d} = \frac{V_b}{V_c}$.

18. (c) : The electric fields are in the same plane, in opposite direction. They cancel each other.



19. (a) : $B = \frac{\mu_0}{4\pi}\cdot\frac{i \cdot 2\lambda a}{a^2} = \frac{\mu_0 I}{2a}$.

The magnetic field is perpendicular to the plane containing the current element and radius. They add to each other.

20. (a) : The potential of the charge

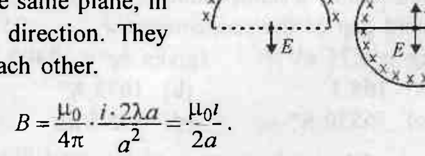
$$A = \frac{1}{4\pi\varepsilon_0}\cdot\frac{Q_1}{r_1} = \frac{1}{4\pi\varepsilon_0}\cdot\frac{5\times10^{-6}c}{0.05}$$

The potential of the charge at B =

$$\frac{1}{4\pi\varepsilon_0}\cdot\frac{Q}{r} = \frac{1}{4\pi\varepsilon_0}\cdot\frac{10\times10^{-6}c}{0.20}$$

Charges flow from a higher to a lower potential therefore charges flow form A to B till their potentials become equal.

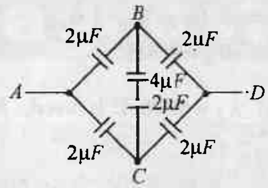
21. (a) :



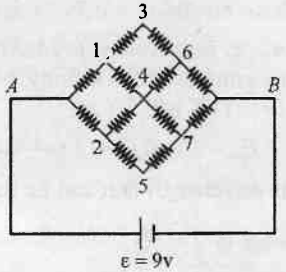
This is the same as one given below.

This is equivalent to a wheatstone's bridge. Therefore the capacitors connected between B and C the total

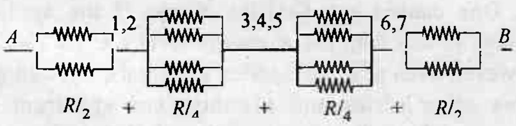
capacitances are $1\mu F$ in the series from A–B–D and $1\mu F$ in A–C–D. They are in parallel. Therefore the total capacitance is $2\mu F$.



22. (a) :

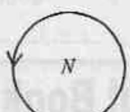


AB is the axis of symmetry 1 and 2; 3, 4, 5; 6, 7 have the same potentials. This is equivalent to



$R_{total} = \frac{3}{2}R$; $R = 1\Omega$ each ; $i = \frac{9\times 2}{3R} = 6A$.

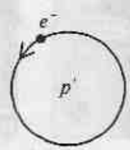
23. (a, c) : Electric dipoles also exist. But any magnet has always a north and a south pole.



Let us consider the magnetic moment of a very thin wire carrying current in the anticlock wise direction. This face is equivalent to the north pole.

If one holds the paper against light, one can see that the current flows in the clockwise direction on the other side. This is equivalent to a south pole as can be verified from the direction of B.

24. (b) : The angular momentum of the electron is $I\omega = mr^2\omega$.



The magnetic moment of the orbiting electron

$$= iA = e\cdot v\cdot \pi r^2 = e\cdot \pi r^2\cdot\frac{\omega}{2\pi}$$

$$\therefore\ \frac{\mu}{L} = e\pi r^2\cdot\frac{\omega}{2\pi}\times\frac{1}{mr^2\cdot\omega} = \frac{e}{2m}.$$

25. (b) : For Bohr orbits, angular momentum $I\omega = n\hbar$.

$$mr^2\cdot\frac{v}{r} = \frac{nh}{2\pi} \Rightarrow mv.\ 2\pi r = nh$$

$$\Rightarrow \frac{nh}{mv} = 2\pi r$$

$$n\cdot\lambda_{\text{de Broglie}} = 2\pi r$$

as $\lambda = \frac{h}{mv}$. Just as one gets a finite number of waves in a given string, or gets $n\cdot\lambda$, 2λ, 3λ for open tubes, $2\pi r = n\cdot\lambda_{\text{de Broglie}}$.

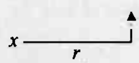
26. Torque replaces force in circular motion. Just as $F = \frac{d}{dt}(mv)$ = rate of change of momentum, torque τ = rate of change of angular momentum.

Mass in translaton is replaced by the moment of inertia in circular motion.

$\therefore$ Mass $\times\ a$ = force, is replaced by

$I\times\alpha = \tau$ where α is the angular acceleration.

Angular momentum is $I.\ \omega$ just as linear momentum is $m.v.$



= moment of momentum or angular momentum

$= r\times mv = mr\omega r = mr^2\omega.$

Rate of change of angular momentum

$$= mr^2 .\frac{d\omega}{dt} = mr^2\cdot\alpha$$

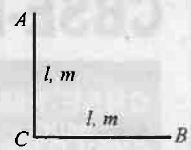
$$= I\alpha$$

ω = angular velocity.

$I\omega$ = Angular momentum.

$I\frac{d\omega}{dt} = I\alpha$ = rate of change of angular momentum = $I\alpha$.

27. For rod A, the value of I about



$$C = \frac{ml^2}{3}$$

For rod B, the value of I about

$$C = \frac{ml^2}{3}$$

$\therefore$ M. I. of A and B about $C = \frac{2ml^2}{3}$.

28. (a) : As the temperature of a semi-conductor increases, electrons in the valence band acquire more energy and they have a probability crossing the potential barrier and start a current. Therefore the temperature decreases the resistance of the semi-conductor.

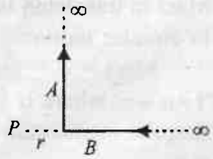
29. (b) : $\frac{hc}{\lambda_1} + \frac{hc}{\lambda_2} = \frac{hc}{\lambda_3} \Rightarrow \frac{\lambda_1+\lambda_2}{\lambda_1\lambda_2} = \frac{1}{\lambda_3}$

$$\Rightarrow \lambda_3 = \frac{\lambda_1\lambda_2}{(\lambda_1+\lambda_2)}.$$

30. (a) : Potential difference across L and R are the same, as they are in parallel circuit. The current in the resistance is in phase with the potential difference but current in L lags by $\pi/2$. Hence the phase difference between the currents in R and L $= -\pi/2$.

(b) The current is the same as C and R are in series. V_{R_2} and I_{R_2} are in phase for R_2 but I_C leads V_C by $\pi/2$. Therefore the phase difference between the potential differences across C and R is $+ 90°$.

31. If the conductors have infinite length, the mag. hield at P = that due to B along the current direction and that due to A at P, $\perp^r$ to the direction at the end.



$\therefore B_{total} = 0 + \frac{\mu_0 I}{4\pi r}$.

32. (d) : $h\nu = hc/\lambda$

$h\nu$, of 4000 A° radiation $= \frac{12400 eVA°}{4000 A°} = 3.1 eV$

K. E. of the electrons $= 1.6\, eV$

$h\nu = W_0$ + K.E. of the electrons (Einstein's equation for photo electricity)

$\Rightarrow 3.1_{eV} = W_0 + 1.6_{eV}$

$\therefore\ W_0 = 1.5 eV$

If $\lambda_2 = 6000 A°$ is used, $h\nu_2 = \frac{12400 eVA°}{6000 A°} = 2.066$ $= 2.1 eV$.

$\therefore$ K.E. of the photo electrons = 2.1 – 1.5 = 0.6 eV.

33. The ionisation energy is the energy needed to remove the electron from the groundstate to infinity. In the case of the H atom, $E_1 = -13.6\ eV$.

Ionisation energy $= E_\infty - E_1 = 0 - (-13.6 eV) = 13.6 eV$.

34. The maximum wavelength that can be detected if the gap energy is Eg is $\lambda = \frac{hc}{E_g}$.

$\lambda_{max} = \frac{12400 eVA°}{0.75 eV} = 16530 A°$.

35. One cannot get K-series X-rays if the applied voltage is less than the K energy level *i.e.* 9.5 KeV.. However, even at lower applied potentials, one can get some other series and a continuous spectrum or Bremsstrahlung. The short wavelength limit is given by $\frac{hc}{\nu} = \frac{12400 eVA°}{8000} = 1.55 A°$.

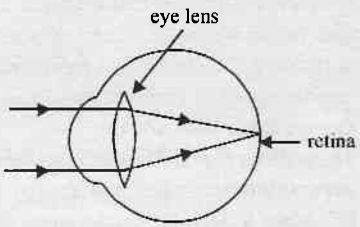
SAMPLE PAPER FOR

IIT-JEE 2006

Based on *New pattern*

(For Q.NO. 1 to 40) Only one option is correct and there will be negative marking in these questions.

PASSAGE : 1 (Read the following passage and answer the questions number 1 to 5. They have only one correct option).



The ciliary muscles of eye control the curvature of the lens in the eye and hence can alter the effective focal length of the system. When the muscles are fully relaxed, the focal length is maximum. When the muscles are strained the curvature of lens increases (that means radius of curvature decreases) and focal length decreases. For a clear vision the image must be on retina. The image distance is therefore fixed for clear vision and it equals the distance of retina from eye-lens. It is about 2.5 cm for a grown-up person.

A person can theoretically have clear vision of objects situated at any large distance from the eye. The smallest distance at which a person can clearly see is related to minimum possible focal length. The ciliary muscles are most strained in this position. For an average grown-up person minimum distance of object should be around 25 cm.

A person suffering for eye defects uses spectacles (eye glass). The function of lens of spectacles is to form the image of the objects within the range in which person can see clearly. The image of the spectacle-lens becomes object for eye-lens and whose image is formed on retina. The number of spectacle-lens used for the remedy of eye defect is decided by the power of the lens required and the number of spectacle-lens is equal to the numerical value of the power of lens with sign. For example power of lens required is +3 D (converging lens of focal length 100/3 cm) then number of lens will be +3.

For all the calculations required you can use the lens formula and lens maker's formula. Assume that the eye lens is equiconvex lens. Neglect the distance between eye lens and the spectacle lens.

1. Minimum focal length of eye lens of a normal person is

(a) 25 cm (b) 2.5 cm (c) $\frac{25}{9}$ cm (d) $\frac{25}{11}$ cm.

2. Maximum focal length of eye lens of normal person is

(a) 25 cm (b) 2.5 cm (c) $\frac{25}{9}$ cm (d) $\frac{25}{11}$ cm.

3. A nearsighted man can clearly see object only upto a distance of 100 cm and not beyond this. The number of the spectacles lens necessary for the remedy of this defect will be

(a) +1 (b) – 1 (c) + 3 (d) – 3

4. A farsighted man cannot see object clearly unless they are at least 100 cm from his eyes. The number of the spectacles lens that will make his range of clear vision equal to an average grown up person

(a) +1 (b) – 1 (c) + 3 (d) – 3

5. A person who can see objects clearly from distance 10 cm to ∞, then we can say that the person is

(a) normal sighted person
(b) near-sighted person
(c) far-sighted person
(d) a person with exceptional eyes having no eye defect

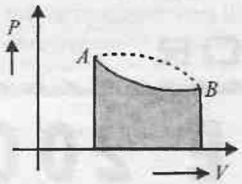
PASSAGE : 2 (Read the following passage and answer the questions number 6 to 10. They have only one correct option)

The concept of work in thermodynamics is borrowed from mechanics. For finite distance moved by the piston from initial position A to final position B. The work

Contributed by Deptt. of Physics, **Resonance**, Kota (Rajasthan)

done by the gas is given by

$$W = \int_A^B PdV$$



P = pressure of gas,
dV = change in volume
In PV diagram work will be area under the curve.

A few comments regarding this integral operator needs to be made. First along the path taken in going from A to B, an equation of state (*i.e.* $P = f(V)$) ***may or may not exist.*** One can express P as a function of V only if the external conditions are changed in such a way that at every point on the path the system can be regarded as an equilibrium state and Such a transformation is called a quasi-static transformation. If the transformation is such that when the sequence of the changes in external conditions are reversed, the system retraces its path from B to A. This transformation is called reversible. All reversible transformations are quasistatic but all quasistatic processes need not be reversible. If the transformation from A to B is not reversible, the transition from A to B cannot be represented by curves on PV diagram. Such transitions are represented by broken lines joining A and B. The spontaneous processes of nature are irreversible. Several example can be cited. The free expansion of a gas is irreversible. The combustion reaction of a mixture of petrol and air ignited by a spark cannot be reversed. Free expansion (expansion of gas against vaccum) differs from all other process.In the case of free expansion work done by the gas is zero although it cannot be calculated by P-V diagram.

Directions for Q. 6 to 10 : *If the given statement is true, then fill bubble for (a) and if given statement is false fill the bubble for (b).*

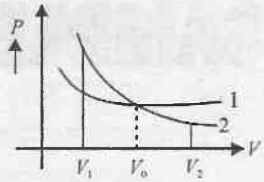
6. All reversible processes are not quasistatic but all quasistatic processes are reversible.

7. In case of free expansion of gas work done by the gas can not be calculated by P-V diagram because free expansion cannot take place reversibally.

8. For non zero pressure of the gas there will be non zero work whenever there will be non zero volume changes of the gas.

9. Total work done by the gas depends upon intermediate process.

10. For volume changes from V_1 to V_0 work done by gas in process 1 will be greater than in process 2.



PASSAGE : 3 (Read the following passage and answer the questions number 11 to 15. They have only one correct option)

Charges are concentrated exclusively on the external surface of a conductor. Therefore neither the material of the conductor nor its mass are of any importance for its capacitance. Capacitance depends on the shape and surface area of the conductor. Since a conductor is liable to be electrified by induction, its capacitance is influenced by other conductors in its vicinity and by the medium they are in.

To fulfil its function the capacitor must be able to store accumulated charges and energy for appreciable time to obtain a definite capacitance one can conveniently take two conductors and arrange them as close to each other as possible and place a dielectric between them. The dielectric between the conductors plays two fold role. Firstly, it increases the capacitance and secondly prevents the neutralization of the charges, that is it prevents them from jumping from one conductor to the other. For this reason electrical breakdown strength (The maximum electrical field which a dielectric can withstand, also called dielectric strength of dielectric) should be high.

In order to keep the capacitance constant and independent of surrounding bodies the entire electric field should be contained between the plates. For this reason the distance between the plates should be small as compared to their linear dimensions. To protect the capacitor from external influences it is housed in a shell. Mathematically we can relate $q = CV$ and for a parallel plate capacitor fully filled with a dielectric $C = \frac{\varepsilon_r \varepsilon_0}{d}$.

According to paragraph answer.

11. Capacitance does not depend on
(a) area of plates
(b) separation between plates
(c) surrounding bodies
(d) potential difference across plates

12. Two plates of a capacitor kept on insulating stand are fully charged. Now the ebonite plate between the

capacitor plates is removed then the capacitance of capacitor will
(a) increase (b) decrease
(c) remains same
(d) may increase or decrease

13. A table for parallel plate capacitors along with the properties of dielectrics used in these is given. Choose the most appropriate capacitor. (Assuming same potential difference across each capacitor)

Capacitor	Dielectric Constant	Dielectric strength (V/M)	Distance between plates (m)	Area of plates (m^2)
A	2.8	3×10^7	0.01 m	0.125
B	3.3	6×10^7	0.01	0.125
C	2.2	7×10^7	0.01	0.25
D	4.4	1×10^7	0.01	0.125

(a) A (b) B (c) C (d) D

14. As the distance between the plates of a parallel plate capacitor is decreased
(a) chances of electrical break down will increase if potential difference between the plates is kept constant.
(b) chances of electrical break down will decrease if potential difference between the plates is kept constant.
(c) chances of electrical break down will increase if charge on the plates is kept constant.
(d) chances of electrical break down will decrease if charge on the plates is kept constant.

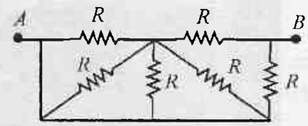
15. All linear dimensions are doubled then the capacitance of the parallel plate capacitor will
(a) remain unchanged (b) become double
(c) increase by eight times
(d) increases by four times

16. A wire of resistance R is cut into two equal parts. Now one part is stretched to double the length. Then the resistance of the stretched wire will be
(a) R (b) $2R$ (c) $4R$ (d) $R/2$

17. A bulb rated 200 W, 200 V is used at 100 V. Then the number of electrons passed through bulb in one second is
(a) 3.125×10^{17} (b) zero
(c) 3.125×10^{18} (d) 6.25×10^{18}

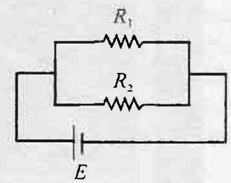
18. Currents upto 100 A are to be measured with the help of an ammeter designed for a maximum current of 10 A and having resistance of 0.1 Ω. The resistance of additional shunt must be
(a) 0.1 Ω (b) 1/9 Ω
(c) 1/100 Ω (d) none of these

19. The equivalent resistance between the points A and B is



(a) $5R/9$
(b) $2R/3$
(c) R (d) none of these.

20. In the given circuit $R_1 > R_2$. Find which of the following statement is correct.

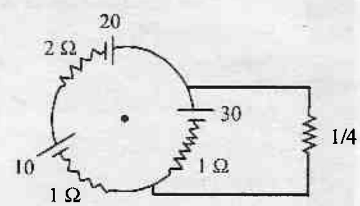


(a) potential difference across R_1 is high
(b) current through R_1 is greater than in R_2
(c) power consumed in R_1 is greater than in R_2
(d) none of these

21. Two particles are moving along a straight line as shown. The velocity of approach between A and B is

(a) $V_A + V_B$ (b) $|V_A - V_B|$
(c) $VA - V_B$ (D) $V_B - V_A$

22. In the following circuit diagram, the current flowing through resistor of 1/4 Ω is

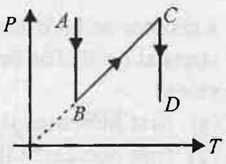


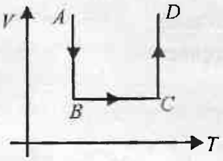
(a) 1 A
(b) 60 A
(c) 30 A (d) none of these

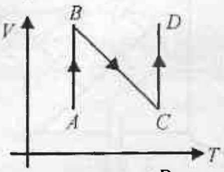
23. A 50 Ampere-hour battery can supply a current of 50 A for 1 hour, 25 A for 2 hour and so on. Then the total energy stored in the 12 V-50 Ampere-hour battery is
(a) 600 J (b) 2.16×10^6 J
(c) depends on for how much time it is used
(d) 3.6×10^4 J

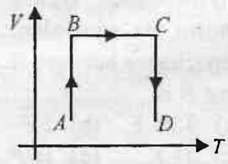
24. For a prism kept in air it is found that for an angle of incidence 60°, the angle of refraction A, angle of deviation δ and angle of emergence 'e' become equal. Then the refractive index of the prism is
(a) 1.73 (b) 1.15 (c) 1.5 (d) 1.33

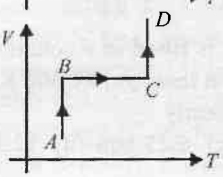
25. P-T diagram is shown below then choose the corresponding V-T diagram



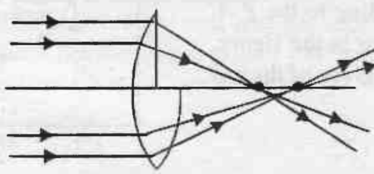
(a)


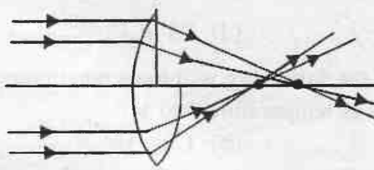
(b)


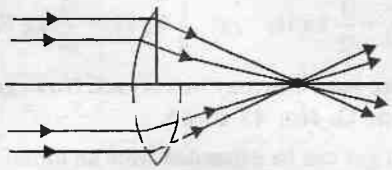
(c)


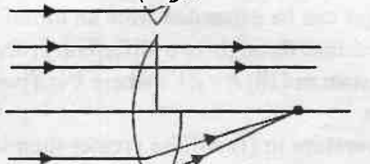
(d)


26. Choose the correct ray diagram of an equi convex lens which is cut as shown.

(a)


(b)


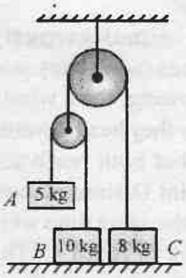
(c)


(d)


27. Ram can throw a ball on a horizontal surface upto a maximum distance of 50 m. The maximum height upto which he can throw the ball is

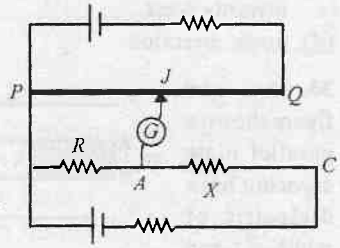
(a) 50 m (b) 25 m
(c) 12.5 m (d) 100 m

28. In the following arrangement the system is initially at rest. The platform is now released. Assuming the pulleys and string to be massless and smooth, the acceleration of block C will be



(a) zero
(b) 2.5 m/s^2 (c) 10/7 m/s^2
(d) 5/7 m/s^2.

29. Circuit for the measurement of resistance by potentiometer is shown. The galvanometer is first connected at point A and zero deflection is observed at length PJ = 10 cm. In second case it is connect at point C and zero deflection is observed at a length 30 cm from P. Then the unknown resistance X is

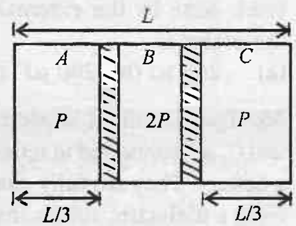


(a) $2R$ (b) $R/2$ (c) $R/3$ (d) $3R$

30. A mango tree is at the bank of a river and one of the branch of tree extends over the river. A tortoise lives in river. A mango falls just above the tortoise. The acceleration of the mango falling from tree appearing to the tortoise is (Refractive index of water is 4/3 and the tortoise is stationary)

(a) g (b) $3g/4$
(c) $4g/3$ (d) none of these

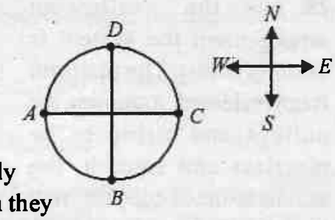
31. Two conducting movable smooth pistons are kept inside a non conducting, adiabatic container with initial positions as shown. Gas is present in the three parts A, B & C having initial pressures as shown. Now the pistons are released. Then the final equilibrium position length of part A will be



(a) $L/8$ (b) $L/4$ (c) $L/6$ (d) $L/5$.

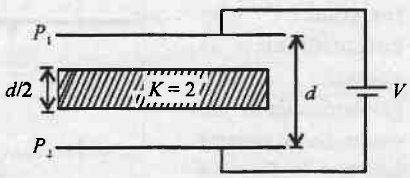
32. Two aeroplanes fly from their respective position A and B starting at the same time and reach the point

C simultaneously when wind was not blowing. On a windy day they head towards C but both reach the point D simultaneously in the same time which they took to reach C. Then the wind is blowing in



(a) north-east direction
(b) north-west direction
(c) direction making an angle $0 < \theta < 90$ with north towards west.
(d) north direction

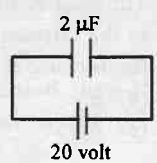
33. In the figure shown a parallel plate capacitor has a dielectric of width $d/2$ and dielectric constant $K = 2$. The other dimensions of the dielectric are same as that of the plates. The plates P_1 and P_2 of the capacitor have area A each. The energy of the capacitor is



(a) $\dfrac{\varepsilon_0 AV^2}{3d}$ (b) $\dfrac{2\varepsilon_0 AV^2}{d}$

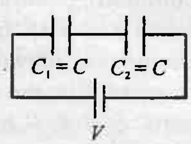
(c) $\dfrac{3}{2}\dfrac{\varepsilon_0 AV^2}{d}$ (d) $\dfrac{2\varepsilon_0 AV^2}{3d}$

34. In the figure a capacitor of capacitance 2 μF is connected to a cell of emf 20 volt. The plates of the capacitor are drawn apart slowly to double the distance between them. The work done by the external agent on the plates is



(a) – 200 μJ (b) 200 μJ (c) 400 μJ (d) – 400 μJ

35. Two identical capacitor C_1 and C_2 are connected in series with a battery. They are fully charged. Now a dielectric slab is inserted between the plates of C_2. The potential difference across C_1 will

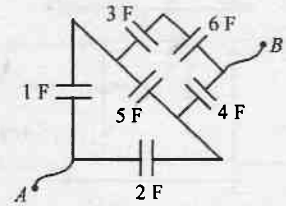


(a) increase (b) decrease
(c) remain same
(d) depend on interval resistance of the cell

36. An uncharged capacitor is connected in series with a resistor and a battery. The charging of the capacitor starts at $t = 0$. The rate at which energy in capacitor is stored

(a) first increases then decreases
(b) first decreases then increases
(c) remains constant
(d) continuously decreases

37. In the figure shown the equivalent capacitance between A and B is

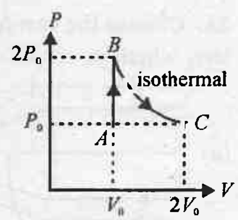


(a) 3.75 F (b) 2 F
(c) 21 F (d) 16 F

38. 12 gm He and 4 gm H_2 is filled in a container of volume 20 litre maintained at temperature 300 K. The pressure of the mixture is nearly

(a) 3 atm (b) 5 atm (c) 6.25 atm (d) 12.5 atm

39. A diatomic ideal gas undergoes a thermodynamic change according to the P–V diagram shown in the figure. The total heat given of the gas is nearly



(a) $2.5\ P_0V_0$
(b) $1.4\ P_0V_0$
(c) $3.9\ P_0V_0$ (d) $1.1\ P_0V_0$

40. Which of the following will have maximum total kinetic energy at temperature 300 K?

(a) 1 kg, H_2 (b) 1 kg, He

(c) $\dfrac{1}{2}$ kg H_2 + $\dfrac{1}{2}$ kg He (d) $\dfrac{1}{4}$ kg H_2 + $\dfrac{3}{4}$ kg He

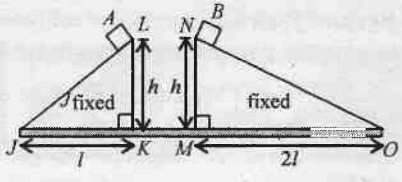
(One or More than one may be correct. No negative marking) For Q. No. 41 to 55.

41. An ideal gas can be expanded from an initial state to a certain volume through two different processes (i) PV^2 = constant and (ii) $P = KV^2$ where K is a positive constant. Then

(a) final temperature in (i) will be greater then in (ii)
(b) final temperature in (ii) will be greater then in (i)
(c) total heat given to the gas in (i) case is greater than in (ii)
(d) total heat given to the gas in (ii) case is greater than in (i)

42. Two identical blocks A and B are placed on two

inclined planes as shown in diagram. Neglect air resistance and other friction



Read the following statements and choose the correct options.

Statement I : Kinetic energy of A on sliding to J will be greater than the kinetic energy of B on falling to M.

Statements II : Acceleration of A will be greater than acceleration of B when both are released to slide on inclined plane

Statements III : Work done by external agent to move block slowly from position B to O is negative

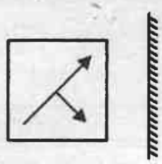
(a) only statement I is true
(b) only statement II is true
(c) only I and III are true
(d) only II and III are true

43. A current I flows through a cylindrical fuse wire of length l, radius r, specific resistance ρ. It is known that the heat radiated per unit area per second is h. This is equal to the electrical power per unit surface area. Therefore h can be expressed as

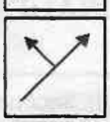
(a) $h=\dfrac{I^2\rho}{2\pi^2r^3}$ (b) $h=\dfrac{I^2\rho}{\pi^2r^4}$

(c) $h=\dfrac{I^2\rho l}{\pi^2r^2}$ (d) $h=\dfrac{I^2\rho}{\pi^2r^3}$

44. Choose the correct mirror-image of figure given below.

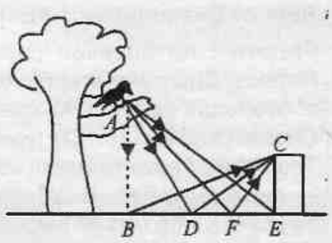


(a) 

(b)  (c) 

(d) 

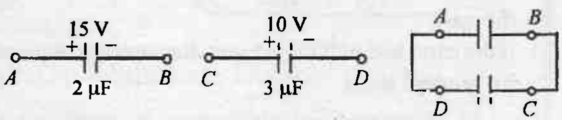
45. A crow is sitting on a branch of a tree and on ground surface wheat grains are spread. The crow flies towards the ground and picks up a grain and sit on the front wall. The possible path are shown in diagram. Choose the correct path so that path length becomes minimum.



Given that $BD = DE$, $\angle AFB = \angle EFC$.

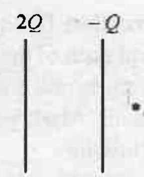
(a) ABC (b) ADC
(c) AFC (d) AEC

46. In the figure initial status of capacitance and their connection is shown. Which of the following is/are correct about this circuit?



(a) final charge on each capacitor will be zero
(b) final total electrical energy of the capacitors will be zero
(c) total charge flown from A to D is 30 μC
(d) total charge flown from A to D is – 30 μC

47. In the figure shown the plates of a parallel plate capacitor have unequal charges. Its capacitance is C. P is a point outside the capacitor and close to the plate of charge $-Q$. The distance between the plates is d.



(a) a point charge at point P will not experience electric force due to capacitor
(b) the potential difference between the plates will be $3Q/2C$
(c) the energy stored in the electric field in the region between the plates is $\dfrac{9Q^2}{8C}$
(d) the force on one plate due to the other plate is $\dfrac{Q^2}{2\pi\varepsilon_0 d^2}$

Directions (For questions from 48 to 50)

You already have some knowledge of the earth and its motion about its own axis and also about the Sun. In this exercise you have to identify the effect of some imaginary conditions. Read statements in Q. 48, 49 and 50 and choose one of (a), (b), (c), (d) out of the following options for each statement to become true.

(a) if the earth were not inclined on its axis
(b) if the orbit of earth were a circle rather than ellipse
(c) if the earth revolved toward west rather than toward the east.
(d) if the earth had half the present diameter but retained its present mass.

48. Statement : The sun would set in the east.

49. Statement : Objects would weigh four times as much as they do now

50. Statement : Night and day would be of equal length in all latitudes all year long.

Direction for questions (51 to 54)

Read each of the following numbered pairs of statement carefully one is an assertion and the second is a possible reason. Mark your answers to question according to followings.

(a) If both assertion and the reason are true and the reason is an adequate explanation of assertion.
(b) If both assertion and the reason are true statements, but the reason does not explain the assertion.
(c) If the assertion is a true statement but reason is a false statement.
(d) If both the assertion and reason are false statements.

51. Assertion : While drawing a line on a paper, friction force acts on paper in the same direction along which line is drawn on the paper.
Reason : Friction always opposes motion.

52. Assertion : For an observer inside the moving train stationary objects outside the train appear to move with different speeds. Objects near the train appears to move faster and object far away appears to move slower.
Reason : Relative velocity of the object is independent of relative position. It only depends on velocity of observer and object but not on their position.

53. Assertion : When an ideal gas is heated in a rigid non conducting container then pressure becomes double if the temperature is doubled.
Reason : Both the frequency of collisions and momentum transferred per collision becomes 2 times.

54. Assertion : We cannot produce electric field in a neutral conductor.
Reason : Neutral conductor cannot produce electric field.

55. Match the following :

Side P	Side Q
(A) Photoelectric effect	I. Photon
(B) Wave	II. Frequency
(C) X rays	III. K capture
(D) Nucleus	IV. γ rays

(a) A – I, B – II, C – III, D – IV
(b) A – II, B – I, C – IV, D – III
(c) A – II, B – I, C – III, D – IV
(d) none of these

ANSWERS

1. (d)	2. (b)	3. (b)	4. (c)	5. (d)
6. (b)	7. (a)	8. (b)	9. (a)	10. (b)
11. (d)	12. (b)	13. (c)	14. (a)	15. (b)
16. (b)	17. (d)	18. (d)	19. (a)	20. (d)
21. (d)	22. (c)	23. (b)	24. (a)	25. (d)
26. (b)	27. (d)	28. (b)	29. (a)	30. (c)
31. (b)	32. (b)	33. (d)	34. (b)	35. (a)
36. (a)	37. (b)	38. (c)	39. (c)	40. (a)
41. (b, d)	42. (d)	43. (a)	44. (c)	45. (c)
46. (a, b, c)		47. (b, c)	48. (c)	49. (d)
50. (a)	51. (c)	52. (b)	53. (a)	54. (d)
55. (a)				

Note : For detailed solutions please log on to our website www.resonance.ac.in

SOLVED PROBLEMS

Practice Question for PMT

1. The damping force for a body moving through a fluid is proportional to velocity. What will be the dimensional formula of the constant of proportionality?
(a) MLT^{-1} (b) ML^0T^{-1}
(c) $ML^{-1}T$ (d) $ML^{-1}T^{-1}$.

2. What should be the angle of projection, so that the horizontal range is equal to the maximum height?
(a) $\tan^{-1}1$ (b) $\tan^{-1}2$
(c) $\tan^{-1}3$ (d) $\tan^{-1}4$.

3. Angle between $\vec{P}$ and $\vec{Q}$ is θ.. What is the value of $\vec{P}\cdot(\vec{Q}\times\vec{P})$?
(a) $P^2Q\cos\theta$ (b) zero
(c) $P^2Q\sin\theta\cos\theta$ (d) $P^2Q\sin\theta$.

4. A block is allowed to slide down an inclined plane of inclination θ. If, the inclined plane is lying on the floor of a lift which is falling down with a retardation a, what will be the acceleration of the block with which it will slide down?
(a) $(g + a)\sin\theta$ (b) $(g - a)\sin\theta$
(c) $g\sin\theta + a$ (d) $g\sin\theta - a$.

5. A thin circular ring of mass M and radius R rotating about its axis with a constant angular speed ω. Two blocks, each of mass m are attached gently to the opposite ends of a diameter of the ring. The angular speed of the ring, will be
(a) $\frac{2M}{M+2m}\omega$ (b) $\frac{M-2m}{M+2m}\omega$
(c) $\frac{M}{M+2m}\omega$ (d) $\frac{M+2m}{M}\omega$

6. The time period (T) of the artificial satellite of earth depends on the density (ρ) of the earth (assumed constant) as
(a) $T\propto\rho$ (b) $T\propto\sqrt{\rho}$
(c) $T\propto 1/\sqrt{\rho}$ (d) $T\propto 1/\rho$.

7. The average kinetic energy of a hydrogen molecule at 27°C is 6.2×10^{-21} joule. The mass of the hydrogen molecule is 3.1×10^{-27} kg. The average kinetic energy at 127°C is
(a) 4.13×10^{-21} joule (b) 5.2×10^{-21} joule
(c) 8.27×10^{-21} joule (d) 2.6×10^{-21} joule.

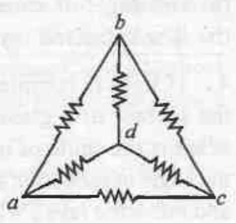
8. Which type of thermodynamics process is the heating of water under atmospheric pressure?
(a) adiabatic (b) isobaric
(c) isochoric (d) none of these.

9. A mass m is suspended from two springs of constants k_1 and k_2 and it oscillates with frequencies f_1 and f_2 respectively. If the same mass is suspended from the same two springs connected in parallel, then the frequency of the combination will be
(a) $f = f_1 + f_2$ (b) $f=\sqrt{f_1 f_2}$
(c) $f=\sqrt{f_1^2+f_2^2}$ (d) $f=\frac{f_1 f_2}{f_1+f_2}$

10. The frequency of an open organ pipe is f. If half part of organ pipe is dipped in water then its frequency is
(a) f (b) $3f/4$
(c) $f/2$ (d) 0.

11. Six charges each equal to $+Q$ are placed at the corners of a regular hexagon of each side x. What is the electric field at the intersection of its diagonals?
(a) $\frac{1}{4\pi\varepsilon_0}\frac{36Q}{x^2}$ (b) $\frac{1}{4\pi\varepsilon_0}\frac{6Q}{x^2}$
(c) $\frac{1}{4\pi\varepsilon_0}\frac{Q}{x^2}$ (d) zero.

12. What is the equivalent resistance between any two corners of the triangle circuit shown below? Each resistance is of 1 Ω?



(a) 1/2 Ω
(b) 1 Ω
(c) 3/2 Ω (d) 2 Ω.

13. A capacitor is charged from a 5 volt battery 100 times per second and is then discharged through a milliammeter 100 tomes per second with the help of

a vibrating switch. What is the capacitance of the capacitor if the current is 0.5 mA?
(a) 1 μF (b) 5 μF
(c) 50 μF (d) 100 μF.

14. An electron and a proton enter a magnetic field at right angle to the field with same kinetic energy. Which of the following is true?
(a) trajectory of electrons is less curved
(b) trajectory of proton is less curved
(c) both are equally curved
(d) both move along straight line paths.

15. A proton and an alpha particle enter in a uniform magnetic field with the same velocity. The period of rotation of the alpha particle will be
(a) four times that of the proton
(b) two times that of the proton
(c) three times that of the proton
(d) same as that of the proton.

16. An air bubble inside a glass slab ($\mu = 1.5$) appears at 6 cm when viewed from one side and 4 cm when viewed from the opposite side. The thickness of the slab is
(a) 10 cm (b) 6.67 cm
(c) 15 cm (d) none of these.

17. X-rays will not show the phenomenon of
(a) diffraction (b) polarisation
(c) deflection by electric field
(d) interference.

18. Einstein photoelectric equation states that $\frac{1}{2}mv^2 = h\upsilon - h\upsilon_0$. In this equation v refers to
(a) velocity of all ejected electrons
(b) mean velocity of emitted electrons
(c) minimum velocity of emitted electrons
(d) maximum velocity of emitted electrons.

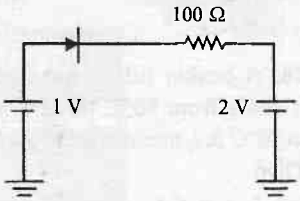
19. A photon and an electron possess same de Broglie wavelength. Given that c = speed of light and v = speed of electron, which of the following relations is correct? Here E_e = kinetic energy of electron, E_{ph} = kinetic energy of photon, p_e = momentum of electron, p_{ph} = momentum of photon.

(a) $\frac{E_e}{E_{ph}} = \frac{2c}{v}$ (b) $\frac{E_e}{E_{ph}} = \frac{v}{2c}$

(c) $\frac{p_e}{p_{ph}} = \frac{2c}{v}$ (d) $\frac{p_e}{p_{ph}} = \frac{c}{2v}$

20. In a nuclear reaction between a deuteron and $_6C^{12}$, the nucleus $_7N^{13}$ is produced. Which is the other particle liberated?
(a) electron (b) positron
(c) proton (d) neutron.

21. Assuming that the junction diode is ideal, in the circuit shown here, the current through the diode is

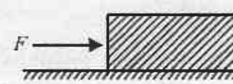


(a) zero
(b) 1 mA
(c) 10 mA (d) 30 mA.

22. A particle of mass $m = 5$ is moving with a uniform speed $v = 3\sqrt{2}$ in the XOY plane along the line $Y = X + 4$. The magnitude of the angular momentum of the particle about the origin is
(a) 60 units (b) $40\sqrt{2}$ units
(c) zero (d) 7.5 units.

23. When a mass is rotating in a plane about a fixed point, its angular momentum is directed along
(a) the radius (b) the tangent to the orbit
(c) a line perpendicular to the plane of rotation
(d) none of these.

24. A block of mass 2 kg is placed on the floor. The coefficient of static friction is 0.4. A force of 2.8 newton is applied on the block as shown in the figure. The force of friction between the block and the floor is (take g = 10 m/s^2)



(a) 2.8 N (b) 8 N
(c) 20 N (d) zero.

25. Moments of inertia of a uniform circular disc about a diameter is I. Its moment of inertia about an axis perpendicular to its plane and passing through a point on its rim will be
(a) $5I$ (b) $3I$
(c) $6I$ (d) $4I$.

26. The largest and the shortest distance of the earth from the sun is r_1 and r_2. Its distance from the sun when it is perpendicular to the major axis of the orbit shown from the sun

(a) $\frac{r_1 + r_2}{4}$ (b) $\frac{r_1 r_2}{r_1 + r_2}$

(c) $\frac{2r_1r_2}{r_1+r_2}$ (d) $\frac{r_1+r_2}{3}$

27. Excess pressure inside a bubble of radius r is P. Then

(a) $P \propto 1/r$ (b) $P \propto r^2$

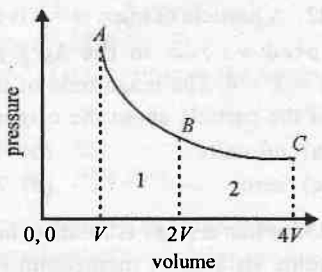
(c) $P \propto r^{-2}$ (d) none of these.

28. A beaker full of hot water is kept in a room and it cools from 80°C to 75°C in t_1 minutes, from 75°C to 70°C in t_2 minutes and from 70°C to 65°C in t_3 minutes. Then

(a) $t_1 < t_2 < t_3$ (b) $t_1 = t_2 = t_3$

(c) $t_1 < t_2 = t_3$ (d) $t_1 < t_2 < t_3$

29. The curve in the adjoining figure shows an isothermal expansion of a given mass of a gas. The area under the curve is divided into two regions. The region 1 is from A to B and the region 2 is from B to C. If the work done in the two regions be denoted by W_1 and W_2 respectively. Then



(a) $W_1 > W_2$ (b) $W_1 < W_2$

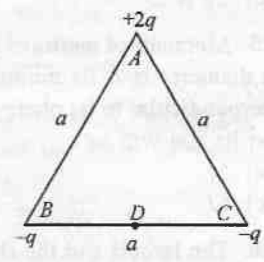
(c) $W_1 = W_2$ (d) $W_1 \gtrless W_2$

30. Two mutually perpendicular simple harmonic vibrations have same amplitude, frequency and phase. When they superimpose, the resultant form of vibration will be

(a) a circle (b) an ellipse

(c) a straight line (d) a parabola.

31. Three charges of $(+2q)$, $(-q)$ and $(-q)$ are placed at the corners A, B and C of an equilateral triangle of side a as shown in the adjoining figure. Then the dipole moment of this combination is



(a) qa (b) zero

(c) $qa\sqrt{3}$ (d) $\frac{2}{\sqrt{3}}qa$

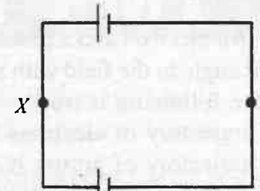
32. Increasing the charge on the plates of a capacitor means

(a) increasing the capacitance

(b) increasing the potential difference between the plates

(c) both (a) and (b) (d) none of these.

33. Two similar accumulators each of emf E and internal resistance r are connected as shown in the adjoining diagram. Then the potential difference between X and Y is



(a) $2E$ (b) E

(c) zero (d) none of these.

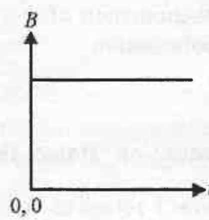
34. Two identical batteries, each of e.m.f. 2 volt and internal resistance 1 ohm are available to produce heat in a resistance $r = 0.5$ by passing a current through it. The maximum joulean power that can be developed across R using these batteries is

(a) 1.28 W (b) 2.0 W

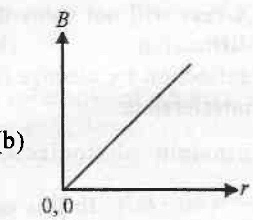
(c) 8/9 W (d) 3.2 W

35. A long straight thin conductor has a current of i ampere. The magnetic induction B away from the conductor at a distance r from its axis varies as shown in

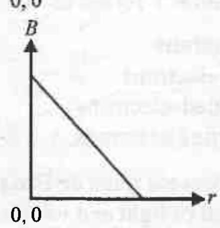
(a)



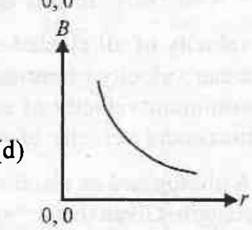
(b)



(c)



(d)



36. The number of turns in the primary and the secondary coils of a transformer are 1000 and 3000 respectively. If 80 volt A.C. is applied to the primary coil of the transformer, then the potential difference per turn of the secondary coil would be

(a) 240 volt (b) 2400 volt

(c) 0.24 volt (d) 0.08 volt.

37. If the potential difference between the cathode and

the target of Coolidge tube is 1.2×10^5 volt then the minimum wavelength of continuous X-rays is
(a) 10 A.u (b) 1 A.u
(c) 0.1 A.u (d) 0.01 Au

38. Light of wavelength 7200 Å in air has a wavelength in glass ($\mu = 1.5$) equal to
(a) 7200 Å (b) 4800 Å
(c) 10800 Å (d) 7201 Å.

39. An achromatic prism is made by combining two prisms P_1 ($\mu_F = 1.532$, $\mu_C = 1.515$) and P_2 ($\mu_F = 1.666$, $\mu_C = 1.650$) μ represents the refractive index. If the angle of the prism P_1 is 10°, the angle of the prism P_2 will be
(a) 5° (b) 78°
(c) 10.6° (d) 20°.

40. In J.J. Thomson's method, electric field $\vec{E}$, magnetic field $\vec{B}$ and velocity v of the electrons were in mutually perpendicular directions. This velocity selector allows particles of velocity v to pass undeflected when
(a) $v = BE$ (b) $v = E/B$
(c) $v = B/E$ (d) $v = B^2/E$.

41. Doubly ionised helium atoms and hydrogen ions are accelerated from rest through the same potential drop. The ratio of the final velocities of the helium and the hydrogen ions is
(a) 2 (b) $\sqrt{2}$
(c) 1/2 (d) $1/\sqrt{2}$

42. The plate current i_p in a triode is given by $i_p = K\left[V_g + \frac{V_p}{\mu}\right]^{3/2}$, then the mutual conductance G_m is related to the plate current as
(a) $G_m \propto (i_p)^{1/3}$ (b) $G_m \propto (i_p)^{2/3}$
(c) $G_m \propto i_p$ (d) $G_m \propto (i_p)^{3/2}$.

43. Momentum of a photon of wavelength λ is
(a) h/λ (b) zero
(c) $h\lambda/c$ (d) hc/λ.

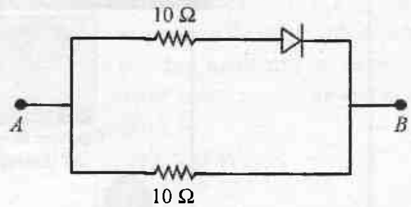
44. If the ionization energy for the hydrogen atom is 13.6 electron volt, the energy required to excite it from the ground state to the next higher state is nearly
(a) 3.4 electron volt (b) 10.2 electron volt
(c) 12.1 electron volt (d) 1.5 electron volt.

45. The probability of a radioactive atom to survive 5 times longer than its half-value period is
(a) 2/5 (b) 2×5
(c) 2^{-5} (d) 2^5.

46. The masses of neutron and proton are 1.0087 and 1.0073 a.m.u respectively. If the neutrons and protons combine to form helium nucleus of mass 4.0015 a.m.u the binding energy of the helium nucleus will be
(a) 28.4 MeV (b) 20.8 MeV
(c) 27.3 MeV (d) 14.2 MeV.

47. When an *pn*-junction diode is reverse biased, the flow of current across the junction is mainly due to
(a) drift of charges (b) diffusion of charges
(c) both drift and diffusion of charges
(d) depends upon the nature of material.

48. If V_A and V_B denote the potentials of A and B, then the equivalent resistance between A and B in the adjoining electric circuit is



(a) 10 ohm if $V_A > V_B$ (b) 5 ohm if $V_A < V_B$
(c) 5 ohm if $V_A > V_B$ (d) 20 ohm if $V_A < V_B$.

49. If the volume of a cubic cell is 10^{-30} m³ then its lattice parameter is
(a) 10^{-30} m (b) $\frac{1}{2} \times 10^{-30}$ m
(c) 10^{-10} m (d) 10^{-15} m.

50. Which of the following gates corresponds to the truth table given below.
(a) NAND
(b) NOR
(c) XOR
(d) OR.

A	B	Y
1	0	0
1	0	1
0	1	1
0	0	1

SOLUTIONS

1. **(b)** : $F = kv$. That is $MLT^{-2} = k\,[LT^{-1}]$
Hence $k = MT^{-1}$.

2. **(d)** : $R = y_m$. That is $\frac{u^2 \sin 2\theta}{g} = \frac{u^2 \sin^2\theta}{2g}$.
Hence, $\sin 2\theta = \frac{1}{2}\sin^2\theta$ or, $2\sin\theta\cos\theta = \frac{1}{2}\sin^2\theta$
or, $\tan\theta = 4$.

3. **(b)** : $\vec{P}$ is perpendicular to $(\vec{Q} \times \vec{P})$. The dot product of perpendicular vector is zero.

4. (a) : The effective value of the downward acceleration is $[g - (-a)]\sin\theta = (g + a)\sin\theta$.

5. (c) : $I\omega = I_1\omega_1$
Here $I = MR^2$, $I_1 = (M + 2m)R^2$
Hence $\omega_1 = M\omega/(M + 2m)$.

6. (c) : $T = 2\pi\sqrt{\dfrac{R^3}{GM}} = 2\pi\sqrt{\dfrac{R^3}{G\times(4/3\pi R^3\rho)}}$

That is $T \propto \dfrac{1}{\sqrt{\rho}}$.

7. (c) : KE $\propto T$, where T is in kelvin.

8. (b)

9. (c) : $f_1 = \dfrac{1}{2\pi}\sqrt{\dfrac{k_1}{m}},\ f_2 = \dfrac{1}{2\pi}\sqrt{\dfrac{k_2}{m}}$
In parallel, $k = k_1 + k_2$.

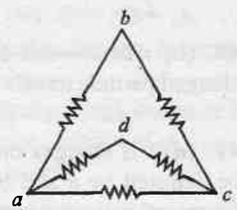
$f = \dfrac{1}{2\pi}\sqrt{\dfrac{k_1 + k_2}{m}}$. That is $f^2 = f_1^2 + f_2^2$.

Frequency of open and closed pipes are $v/2l$ and $v/4l$ respectively.

10. (a)

11. (d) : Electric fields due to the charges at the opposite corners will cancel each other.

12. (a) : Suppose we want to find the resistance across a and c. The symmetry of the distribution current requires that there should be same current in the parts ab and bc. Same is true for the parts ad and dc. This is possible only when there is no current through the part bd. Hence equivalent circuit is as shown in the figure. And the equivalent resistance across a and c is $1/2\ \Omega$.



13. (a) : Here $5 \times C \times 100 = 0.5 \times 10^{-3}$
This gives $C = 1\ \mu$F.

14. (b) : Radius of the circular path is $R = \dfrac{Mv\sin\phi}{q_0 B}$.
Since, mass of electron is less, so its radius will also be small. The radius of the proton will be more than that. Hence, curvature of the trajectory of the proton will be less. Remember, curvature = 1/radius.

15. (b) : In this case, $T = \dfrac{2\pi M}{qB}$

And $\dfrac{T_1}{T_2} = \dfrac{M_1}{q_1} \times \dfrac{q_2}{M_2}$
Let T_1, M_1, q_1 be the time period, mass and charge of proton and T_2, M_2, q_2 that for α-particle. Then

$$T_2 = T_1\frac{q_1}{q_2} \times \frac{M_2}{M_1}$$

Here $q_2 = 2q_1$ and $M_2 = 4M_1$. Hence,

$$T_2 = T_1 \times \frac{1}{2} \times 4 = 2T_1.$$

16. (c) : $\mu = \dfrac{\text{real depth}}{6} = \dfrac{\text{thickness} - \text{real depth}}{4}$

17. (c) : X-rays consists of photons, which do not carry charge.

18. (d) : It is the maximum kinetic energy of the electron, when minimum amount of energy is used to take the electron out.

19. (b) : $E_e = \dfrac{1}{2}mv^2 = \dfrac{1}{2}\times(mv)v = \dfrac{1}{2}\dfrac{h}{\lambda}v$.

For photon, $E_{ph} = \dfrac{hc}{\lambda}$.

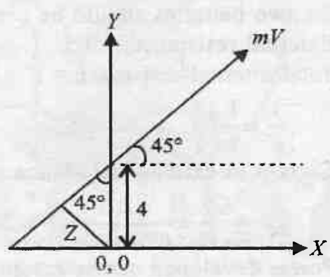
20. (d) : ${}_1D^2 + {}_6C^{12} \rightarrow {}_7N^{13} + {}_aY^b$
Here $a = 6 + 1 - 7 = 0$, $b = 2 + 12 - 13 = 1$
And ${}_0Y^1$ is neutron.

21. (a) : The diode is reverse biased so the current through it is zero.

22. (a) : Momentum of the particle
= mass × velocity

$= (5)\times(3\sqrt{2}) = 15\sqrt{2}$.

The direction of momentum in the XOY plane is given by
$y - x + 4$.



Slope of the line = 1
= $\tan\theta$. *i.e.* $\theta = 45°$
Intercept of this straight line = 4
Length of the perpendicular z from the origin on the straight line = $4\sin 45° = \dfrac{4}{\sqrt{2}} = 2\sqrt{2}$.

Angular momentum = momentum × perpendicular distance

$$= (15\sqrt{2})(2\sqrt{2}) = 60 \text{ units}.$$

23. (c)

24. (a) : Limiting force of friction = μR
$= \mu Mg = 0.4 \times 2 \times 10 = 8$ N.

As external applied force of 2.8 newton is less than than limiting friction, the actual force of friction is equal to the external force of 28 newton but in opposite direction.

25. (c) **26. (b)** **27. (a)** **28. (a)**

29. (c) **30. (c)**

31. (c) : If D is the middle point of the line joining B and C, then charges of $(-q)$ and $(-q)$ placed at B and C can be replaced by a charge $(-2q)$ placed at D.

Now $AD = (AB)\sin 60° = a\left(\frac{\sqrt{3}}{2}\right)$

Electric dipole moment $= 2q\left[\sqrt{\frac{a\sqrt{3}}{2}}\right] = qa\sqrt{3}.$

Positive direction of dipole moment is from D to A *i.e.* along the bisector of the angle at A but away from the base of the triangle.

32. (b)

33. (c) : Let current in the circuit be i then i is given by
$E + E = ir + ir$ or, $i = E/r$.

Now, $V_x - V_y = E - ir = E - \frac{E}{r}\times r = E - E = 0.$

34. (b) : For maximum power in the external resistance external resistance = total internal resistance. Hence the two batteries should be connected in parallel.
External resistance = 0.5.
Total internal resistance = r'

$\frac{1}{r'} = \frac{1}{1} + \frac{1}{1}$ or, $r' = 0.5$

Current in external resistance

$i = \frac{E}{r + r'} = \frac{2}{0.5 + 0.5} = \frac{2}{1} = 2$ ampere.

Power developed across external resistance = $I^2 r$
$= 2^2 \times 0.5 = 2$ watt.

35. (d) : $B \propto 1/r$.

36. (d) : For a transformer, $\frac{E_s}{E_p} = \frac{N_s}{N_p}$

$\therefore \frac{E_s}{N_s} = \frac{E_p}{N_p}$. Now, $\frac{E_p}{N_p} = \frac{80}{1000} = 0.08$

$\therefore \frac{E_s}{N_s} = 0.08\ \frac{\text{volt}}{\text{turn}}.$

37. (c) : When the potential difference between the cathode and the anticathode is V volt, then the minimum wavelength λ_{min} of continuous X-rays is given by

$\lambda_{min} = hc/eV$

Here $h = 6.6 \times 10^{-34}$ joule $\times$ sec
$c = 3 \times 10^8$ m/sec, $e = 1.6 \times 10^{-19}$ C

$$\lambda_{min} = \frac{6.6\times10^{-34}\times3\times10^8}{1.6\times10^{-19}\ \text{V}}$$

$V = 1.2 \times 10^5 = 120000$ eV
$hc = 12400$ eV Å

$$\therefore \lambda_{min} = \frac{12400\ \text{eV Å}}{120000} = 0.7\ \text{Å}.$$

38. (b) : ${}^a\mu_g = \frac{\lambda_a}{\lambda_g}$.

Here ${}^a\mu_g = 1.5$, $\lambda_a = 7200$ Å

$$\therefore \lambda_g = \frac{\lambda_a}{{}^a\mu_g} = \frac{7200}{1.5} = 4800\ \text{Å}.$$

39. (a) : For an achromatic combination of two prisms P_1 and P_2, the angular disperson θ_1 and θ_2 are numerically equal.

i.e. $\theta_1 = \theta_2$
$(1\mu_F - 1\mu_C)A_1 = (2\mu_F - 2\mu_C)A_2$
i.e. $(1.523 - 1.515)10° = (1.666 - 1.650)A_2$
or, $(0.008)(10°) = (0.016)A_2$
$\therefore A_2 = 5°$.

40. (b) : In crossed electric and magnetic field the charged particle travels straight with no deflection when
$Bev = Ee$. $\therefore v = E/B$.

41. (d) : If charges on helium ion and hydrogen ion be denoted by q and q'.
Energyof helium ion = qV
Energy of hydrogen ion = $q'V$
where V is the potential difference through which either of these ions is accelerated.
If V_{He} and V_H denote the final velocities of helium ions and hydrogen ions and M_{He} and M_H the masses of helium ions and hydrogen ions. Then

$$\frac{\frac{1}{2}M_{He}V_{He}^2}{\frac{1}{2}M_H V_H^2} = \frac{qV}{q'V}\ ;\ \left(\frac{V_{He}}{V_H}\right)^2 = \left(\frac{q}{q'}\right)\left(\frac{M_H}{M_{He}}\right)$$

Here, $\frac{q}{q'} = \frac{2}{1}$ and $\frac{M_H}{M_{He}} = \frac{1}{4}$

$$\therefore \left(\frac{V_{He}}{V_H}\right)^2 = \left(\frac{2}{1}\right)\left(\frac{1}{4}\right) = \frac{1}{2} \Rightarrow \frac{V_{He}}{V_H} = \frac{1}{\sqrt{2}}.$$

42. (a) : For a triode, $i_p = K\left[V_g + \frac{V_p}{\mu}\right]^{3/2}$ ... (i)

$$\left(\frac{di_p}{dV_g}\right)_{V_P=\text{constant}} = K\left(\frac{3}{2}\right)\left(V_g + \frac{V_p}{\mu}\right)^{1/2}$$

Now, $\left(V_g + \frac{V_p}{\mu}\right)^{1/2} = \left(\frac{i_p}{K}\right)^{1/3}$

$$\therefore \left(\frac{di_p}{dV_g}\right)_{V_p\ =\ \text{constant}} = \frac{3}{2}K\left[\frac{i_p}{K}\right]^{1/3} = \frac{3}{2}K^{2/3}(i_p)^{1/3}.$$

But $\left(\frac{di_p}{dV_g}\right)_{V_p\ =\ \text{constant}} = G_m$

$$\therefore \quad G_m = \frac{3}{2}K^{2/3}(i_p)^{1/3}.$$

43. (a) **44. (b)**

45. (c) : Here $t/t_h = 5 = n$

But $N/N_0 = (1/2)^n = (1/2)^5$. $\therefore$ $N/N_0 = 2^{-5}$.

Survival probability of a radioactive atom = 2^{-5}.

46. (a) : $\Sigma m_r = 2\,[1.0087 + 1.0073]$
= 2 [2.0160] amu = 4.0320 a.m.u

$\Sigma m_p = 4.0015$ a.m.u

Decrease in mass when two protons and two neutrons combine to form helium nucleus
= (4.0320 – 4.0015) amu
= 0.0305 amu = (0.0305)(931) MeV
= 28.4 MeV.

47. (b)

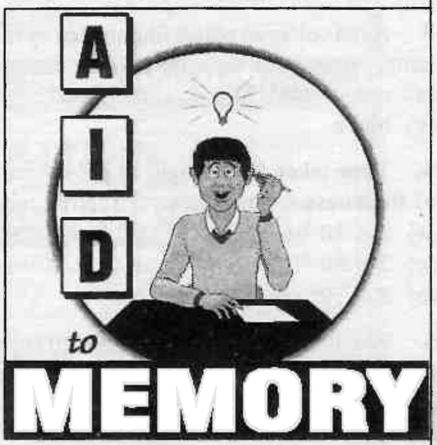
48. (c) : When $V_A > V_B$, the junction diode is forward biased biased and hence conducting. Then the two ten ohm resistors are arranged in parallels.

$$\frac{1}{R_{AB}} = \frac{1}{10} + \frac{1}{10} = \frac{2}{10} = \frac{1}{5}$$

$\therefore$ $R_{AB} = 5$ ohm.

49. (c) : Let the lattice parameter be a, then
$a^3 = 10^{-30}\ \text{m}^3$. $\therefore$ $a = 10^{-10}$ m.

50. (a)



Contributed by Neha Chandak, Nagpur

Dear Students, We know that its too difficult to remember The spectral classification sequence (star classes on a stellar evolution diagram). So we are presenting some *mneumonics* to learn few very difficult things in Physics in a very easy way.

1. **The different categories of radiation, in order of increasing wavelength**
   Cary grant expects unanimous votes in movie reviews tonight.
   Cosmic, gamma, X-rays, ultraviolet, visible, infrared, microwave, radio, television.
2. **Whether current leads voltage or lags it in reactive circuits**
   Think of '**Eli the Ice man**'. In inductive (L) circuits, voltage (E) leads current (I), hence **ELI**. In capacitive (C) circuits, it is the other way, so **ICE**.
3. **The direction in which the current flows in a thermocouple made from antimony and bismuth metals**
   abc - The current flows from the antimony to the bismuth through the cold junction.
4. **The definition of mechanical advantage**
   Men always like eating.
   MA - load over effort (1/e)
5. **The order of ohmic values in resistors**
   Billy brown relies on your gin but prefers good whiskey.
   Black/brown/red/orange/yellow/green/blue/purple/grey/white.

If you have such mneumonics in Physics, Chemistry, Botany or Zoology which can be proved as aid to memory then send them to us. On selection we will publish them with your name in our monthly magazines Physics For You, Chemistry Today and Biology Today.

SOLVED PAPER

KERALA PET - 2005

1. The frequency of X-rays, γ-rays and ultraviolet rays are respectively a, b and c, then
(a) $a < b,\ b > c$ (b) $a > b,\ b > c$
(c) $a > b,\ b < c$ (d) $a < b,\ b < c$
(d) $a = b = c$.

2. If c is the speed of electromagnetic waves in vacuum, its speed in a medium of dielectric constant K and relative permeability μ_r is
(a) $v = \frac{1}{\sqrt{\mu_r K}}$ (b) $v = c\sqrt{\mu_r K}$
(c) $v = \frac{c}{\sqrt{\mu_r K}}$ (d) $v = \frac{K}{\sqrt{\mu_r c}}$
(e) $v = \frac{\mu_r}{\sqrt{cK}}$

3. A red coloured object illuminated by mercury vapour lamp, when seen through a green filter, will appear
(a) red (b) blue (c) violet (d) white
(e) black.

4. Time taken by sunlight to pass through a window of thickness 4 mm whose refractive index is 3/2 is
(a) 2×10^{-4} sec (b) 2×10^{4} sec
(c) 2×10^{-11} sec (d) 2×10^{11} sec
(e) 2×10^{8} sec.

5. Two thin lenses of focal length 20 cm and 25 cm are in contact. The effective power of the combination is
(a) 4.5 D (b) 18 D (c) 45 D (d) 2.5 D
(e) 9 D.

6. The magnification of the image when an object is placed at a distance x from the principal focus of a mirror of focal length f is
(a) $\frac{x}{f}$ (b) $1+\frac{f}{x}$ (c) $\frac{f}{x}$ (d) $1-\frac{f}{x}$
(e) $\frac{1+f}{x}$.

7. In the Young's double slit experiment, the central maxima is observed to be I_0. If one of the slits is covered then the intensity at the central maxima will become
(a) $I_0/2$ (b) $I_0/\sqrt{2}$ (c) $I_0/4$ (d) I_0
(e) I_0^2.

8. The ratio of the de-Broglie wavelength of an α-particle and a proton of same kinetic energy is
(a) 1 : 2 (b) 1 : 1 (c) $1 : \sqrt{2}$ (d) 4 : 1
(e) $\sqrt{2} : 1$.

9. Which of the following is not conserved in nuclear reaction?
(a) total energy (b) mass number
(c) charge number (d) nucleon number
(e) number of fundamental particles.

10. The number of α-particles and β-particles respectively emitted in the reaction : ${}_{88}A^{196} \rightarrow {}_{78}B^{164}$ are
(a) 8 and 8 (b) 8 and 6
(c) 6 and 8 (d) 6 and 6
(e) 8 and 4.

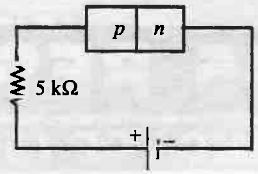
11. The counting rate observed from a radioactive source at $t = 0$ second was 1600 counts per second and $t = 8$ seconds it was 100 counts per second. The counting rate observed as counts per second $t = 6$ seconds will be
(a) 400 (b) 300 (c) 250 (d) 200
(e) 150.

12. If D_e, D_b and D_c are the doping levels of emitter, base and collector respectively of a transistor, then
(a) $D_e = D_b = D_c$ (b) $D_e < D_b = D_c$
(c) $D_e > D_b > D_c$ (d) $D_e < D_b < D_c$
(e) $D_e > D_c > D_b$.

13. The relation between α and β parameters of a transistor is
(a) $\alpha = \frac{1+\beta}{\beta}$ (b) $\alpha = \frac{1-\beta}{\beta}$
(c) $\alpha = \frac{\beta}{1+\beta}$ (d) $\alpha = \frac{\beta}{1-\beta}$
(e) $\alpha = \beta$.

14. A p-n junction in series with a resistance of 5 kΩ

is connected across a 50 V DC source. If the forward bias resistance of the junction is 50 Ω, the forward bias current is



(a) 8.8 mA (b) 1 mA
(c) 2 mA (d) 20 mA (e) 9.9 mA.

15. A transistor connected at common emitter mode contains load resistance of 5 kΩ and an input resistance of 1 kΩ. If the input peak voltage is 5 mV and the current gain is 50, find the voltage gain.
(a) 250 (b) 500 (c) 125 (d) 50
(e) 75.

16. If n_1 and n_2 are the refractive indices of the core and the cladding respectively of an optic fibre, then
(a) $n_1 = n_2$ (b) $n_1 < n_2$
(c) $n_2 < n_1$ (d) $n_2 = 2n_1$
(e) $n_2 = \sqrt{2n_1}$.

17. If a radio receiver amplifies all the signal frequencies equally well, it is said to have high
(a) fidelity (b) distortion
(c) sensibility (d) sensitivity
(e) selectivity.

18. If a radio receiver is tuned to 855 kHz radio wave, the frequency of local oscillator in kHz is
(a) 1510 (b) 455 (c) 1310 (d) 1500
(e) 855.

19. A TV tower has a height of 100 m. What is the maximum distance upto which the TV transmission can be received ($R = 8 \times 10^6$ m)?
(a) 34.77 km (b) 32.70 km
(c) 40 km (d) 40.70 km
(e) 42.75 km.

20. The dimensional formula of magnetic flux is
(a) $[M^1L^0T^{-2}A^{-1}]$ (b) $[M^1L^2T^{-1}A^{-1}]$
(c) $[M^1L^2T^{-1}A^{-2}]$ (d) $[M^1L^2T^0A^{-1}]$
(e) $[M^1L^2T^{-2}A^{-1}]$

21. A physical quantity A is related to four observable a, b, c and d as follows. $A = \dfrac{a^2b^3}{c\sqrt{d}}$
The percentage errors of measurement in a, b, c and d are 1%, 3%, 2% and 2% respectively. What is the percentage of error in the quantity A?
(a) 12% (b) 7% (c) 5% (d) 16%
(e) 14%.

22. A body starting from rest moves with constant acceleration. The ratio of distance covered by the body during the 5^{th} second to that covered in 5 seconds is
(a) 9/25 (b) 3/5 (c) 25/9 (d) 1/25
(e) 25.

23. The area under acceleration-time graph gives
(a) distance travelled (b) change in acceleration
(c) force acting (d) change in velocity
(e) work done.

24. A particle is displaced from a position $(2\hat{i} - \hat{j} + \hat{k})$ to another position $(3\hat{i} + 2\hat{j} - 2\hat{k})$ under the action of the force of $(2\hat{i} + \hat{j} - \hat{k})$. The work done by the force in an arbitrary unit is
(a) 8 (b) 10 (c) 12 (d) 16
(e) 20.

25. From the top of tower, a stone is thrown up. It reaches the ground in t_1 s. A second stone thrown down with the same speed reaches the ground in t_2 s. A third stone released from rest reaches the ground in t_3 s. Then
(a) $t_3 = \dfrac{t_1 + t_2}{2}$ (b) $t_3 = \sqrt{t_1 t_2}$
(c) $\dfrac{1}{t_3} = \dfrac{1}{t_1} - \dfrac{1}{t_2}$ (d) $t_3^2 = t_2^2 - t_1^2$
(e) $t_3 = \dfrac{t_1 - t_2}{2}$

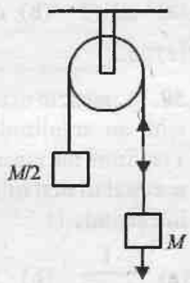
26. An object is projected at an angle of 45° with the horizontal. The horizontal range and maximum height reached will be in the ratio
(a) 1 : 2 (b) 2 : 1 (c) 1 : 4 (d) 4 : 1
(e) $4 : \sqrt{2}$

27. If the length of the second's hand in a stop-clock is 3 cm, the angular velocity and linear velocity of the tip is
(a) 0.2047 rad/s, 0.0314 ms^{-1}
(b) 0.2547 rad/s, 0.314 ms^{-1}
(c) 0.1472 rad/s, 0.06314 ms^{-1}
(d) 0.1047 rad/s, 0.00314 ms^{-1}
(e) 0.347 rad/s, 0.134 ms^{-1}.

28. A player caught a cricket ball of mass 150 g moving at the rate of 20 ms^{-1}. If the catching process be completed in 0.1 s the force of the blow exerted by the ball on the hands of the player is
(a) 0.3 N (b) 30 N (c) 300 N (d) 3000 N
(e) 3 N.

29. A uniform metal chain is placed on a rough table such that one end of chain hangs down over the edge of the table. When one-third of its length hangs over the edge, the chain starts sliding. Then, the coefficient of static friction is
(a) 3/4 (b) 1/4 (c) 2/3 (d) 1/3
(e) 1/2.

30. Two masses M and $M/2$ are joined together by means of light inextensible string passed over a frictionless pulley as shown in the figure. When the bigger mass is released, the small one will ascent with an acceleration of



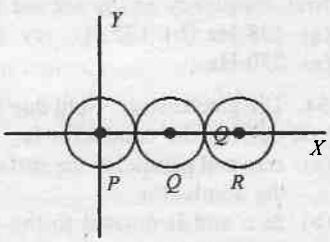
(a) $g/3$ (b) $3g/2$
(c) $g/2$ (d) g (e) $g/4$.

31. In elastic collision
(a) both momentum and kinetic energies are conserved
(b) both momentum and kinetic energies are not conserved
(c) only energy is conserved
(d) only mechanical energy is conserved
(e) only momentum is conserved.

32. A ball is released from the top of a tower. The ratio of work done by force of gravity in first, second and third second of the motion of the ball is
(a) 1 : 2 : 3 (b) 1 : 4 : 9
(c) 1 : 3 : 5 (d) 1 : 5 : 3
(e) 1 : 3 : 2

33. When the kinetic energy of a body is doubled, its momentum increases by .... times.
(a) $\sqrt{2}$ (b) 2 (c) 4 (d) $2\sqrt{2}$
(e) $1/\sqrt{2}$

34. Three identical spheres, each of mass 1 kg are kept as shown in figure, touching each other, with their centres on a straight line. If their centres are marked P, Q, R respectively, the distance of centre of mass of the system from P is



(a) $\frac{PQ+PR+QR}{3}$ (b) $\frac{PQ+PR}{3}$
(c) $\frac{PQ+QR}{3}$ (d) $\frac{PR+QR}{3}$
(e) $\frac{PQ+QR+PR}{3}$.

35. The moment of inertia of a thin rod of mass M and length L about an axis perpendicular to the rod at a distance $L/4$ from one end is
(a) $\frac{ML^2}{6}$ (b) $\frac{ML^2}{12}$ (c) $\frac{7ML^2}{24}$ (d) $\frac{7ML^2}{12}$
(e) $\frac{7ML^2}{48}$

36. A body rolls down an inclined plane. If its kinetic energy of rotation is 40% of its kinetic energy of translation, then the body is
(a) solid cylinder (b) solid sphere
(c) disc (d) ring
(e) hollow cylinder.

37. Which of the following statements about the gravitational constant is true?
(a) it is a force (b) it has no unit
(c) it has same value in all systems of units
(d) it depends on the value of the masses
(e) it does not depend on the nature of the medium in which the bodies are kept.

38. Four particles each of mass M, are located at the vertices of a square with side L. The gravitational potential due to this at the centre of the square is
(a) $-\sqrt{32}\frac{GM}{L}$ (b) $-\sqrt{64}\frac{GM}{L^2}$
(c) zero (d) $\sqrt{32}.\frac{GM}{L}$
(e) $8\frac{GM}{L^2}$.

39. Two identical solid copper spheres of radius R are placed in contact with each other. The gravitational attraction between them is proportional to
(a) R^2 (b) R^{-2} (c) R^4 (d) R^{-4}
(e) R^3.

40. The modulus of elasticity is dimensionally equivalent to
(a) strain (b) force
(c) stress (d) coefficient of viscosity
(e) surface tension.

41. Radius of an air bubble at the bottom of the lake is r and it becomes $2r$ when the air bubbles rises to the top surface of the lake. If P cm of water be the atmospheric pressure, then the depth of the lake is

(a) $2P$ (b) $8P$ (c) $4P$ (d) $7P$
(e) $5P$.

42. A manometer connected to a closed tap reads 4.5×10^5 pascal. When the tap is opened the reading of the manometer falls to 4×10^5 pascal. Then the velocity of flow of water is
(a) 7 ms^{-1} (b) 8 ms^{-1} (c) 9 ms^{-1} (d) 12 ms^{-1}
(e) 10 ms^{-1}.

43. What is the velocity v of a metallic ball of radius r falling in a tank of liquid at the instant when its acceleration is one-half that of a freely falling body? (The densities of metal and of liquid are ρ and σ respectively, and the viscosity of the liquid is η).
(a) $\frac{r^2 g}{9\eta}(\rho - 2\sigma)$ (b) $\frac{r^2 g}{9\eta}(2\rho - \sigma)$
(c) $\frac{r^2 g}{9\eta}(\rho - \sigma)$ (d) $\frac{2r^2 g}{9\eta}(\rho - \sigma)$
(e) $\frac{r^2 g}{18\eta}(\rho - 2\sigma)$

44. A black body has maximum wavelength λ_m at 2000 K. Its corresponding wavelength at 3000 K will be
(a) $\frac{3}{2}\lambda_m$ (b) $\frac{2}{3}\lambda_m$ (c) $\frac{16}{81}\lambda_n$ (d) $\frac{81}{16}\lambda_m$
(e) $\frac{4}{3}\lambda_m$

45. The value of PV/T for one mole of an ideal gas is nearly equal to
(a) 2 J mol^{-1} K^{-1} (b) 8.3 cal mol^{-1} K^{-1}
(c) 4.2 J mol^{-1} K^{-1} (d) 2 cal mol^{-1} K^{-1}
(e) 4 cal mol^{-1} K^{-1}.

46. The volume of a metal sphere increases by 0.24% when its temperature is raised by 40°C. The coefficient of linear expansion of the metal is .... °C.
(a) 2×10^{-5} (b) 6×10^{-5}
(c) 18×10^{-5} (d) 1.2×10^{-5}
(e) 2.1×10^{-5}.

47. The temperature of equal masses of three different liquids A, B and C are 12°C, 19°C and 28°C respectively. The temperature when A and B are mixed is 16°C and when B and C are mixed is 23°C. The temperature when A and C are mixed is
(a) 18.2°C (b) 22°C (c) 20.2°C (d) 25.2°C
(e) 20.8°C.

48. The time period of the seconds hand of a watch is
(a) 1 hour (b) 1 s (c) 12 hours
(d) 1 minute (e) 0.1 hour.

49. A particle starts simple harmonic motion from the mean position. Its amplitude is a and total energy E. At one instant its kinetic energy is $3E/4$. Its displacement at that instant is
(a) $a/\sqrt{2}$ (b) $a/2$ (c) $\frac{a}{\sqrt{3/2}}$ (d) $a/\sqrt{3}$
(e) a.

50. A particle executes linear simple harmonic motion with an amplitude of 2 cm. When the particle is at 1 cm from the mean position the magnitude of its velocity is equal to that of its acceleration. Then its time period in seconds is
(a) $\frac{1}{2\pi\sqrt{3}}$ (b) $2\pi\sqrt{3}$ (c) $\frac{2\pi}{\sqrt{3}}$ (d) $\frac{\sqrt{3}}{2\pi}$
(e) $\frac{\sqrt{3}}{\pi}$.

51. A closed organ pipe and an open organ pipe are tuned to the same fundamental frequency. The ratio of their lengths is
(a) 1 : 1 (b) 2 : 1 (c) 1 : 4 (d) 1 : 2
(e) 4 : 1.

52. An observer standing near the sea shore observes 54 waves per minute. If the wavelength of the water wave is 10 m then the velocity of water wave is
(a) 540 ms^{-1} (b) 5.4 ms^{-1}
(c) 0.184 ms^{-1} (d) 9 ms^{-1}
(e) 48.6 ms^{-1}.

53. A set of 24 tuning forks are so arranged that each gives 6 beats per second with the previous one. If the frequency of the last tuning fork is double that of the first, frequency of the second tuning fork is
(a) 138 Hz (b) 132 Hz (c) 144 Hz (d) 276 Hz
(e) 270 Hz.

54. The electrostatic field due to a charged conductor just outside the conductor is
(a) zero and parallel to the surface at every point inside the conductor
(b) zero and is normal to the surface at every point inside the conductor
(c) parallel to the surface at every point and zero inside the conductor
(d) normal to the surface at every point and zero inside the conductor
(e) normal to the surface at every point and non-zero inside the conductor.

55. A point charge $+q$ is placed at the mid-point of a cube of side a. The electric flux emerging from the cube is

(a) zero (b) $\frac{3qa^2}{\varepsilon_0}$ (c) $\frac{q}{\varepsilon_0}$ (d) $\frac{\varepsilon_0}{4qa^2}$

(e) ε_0/q.

56. Figure shows four plates each of area A and separated from another by a distance d. What is the capacitance between P and Q?

(a) $\frac{\varepsilon_0 A}{d}$ (b) $\frac{2\varepsilon_0 A}{d}$ (c) $\frac{3\varepsilon_0 A}{d}$ (d) $\frac{4\varepsilon_0 A}{d}$

(e) zero.

57. A soap bubble is charged to a potential of 16 V. Its radius is then doubled. The potential of the bubble now will be

(a) 16 V (b) 8 V (c) 4 V (d) 2 V

(e) zero.

58. A parallel plate capacitor of capacitance of 10 μF is charged to 1 μC. The charging battery is removed and then the separation between the plates is doubled. Work done during the process is

(a) 5 μJ (b) 0.05 μJ (c) 1 μJ (d) 10 μJ

(e) 50 μJ.

59. A 10 Ω electric heater operates on a 110 V line. The rate at which heat is developed in watts is

(a) 1310 W (b) 670 W (c) 810 W (d) 1210 W

(e) 1100 W.

60. For a certain thermocouple, if the temperature of the cold junction is 0°C, the neutral temperature and inversion temperatures are 285°C and 570°C respectively. If the cold junction is brought to 10°C, then the new neutral and inversion temperatures are respectively

(a) 285°C and 560°C (b) 285°C and 570°C

(c) 295°C and 560°C (d) 275°C and 560°C

(e) 275°C and 570°C.

61. In which of the following substances does resistance decrease with increase in temperature?

(a) copper (b) carbon

(c) constantan (d) silver

(e) sodium.

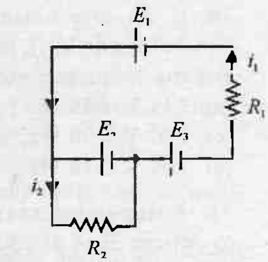
62. Resistors P and Q connected in the gaps of the meter bridge. The balancing point is obtained 1/3 m from the zero end. If a 6 Ω resistance is connected in series with P the balance point shifts to 2/3 m from same end. P and Q are

(a) 4, 2 (b) 2, 4

(c) both (a) and (b) (d) neither (a) nor (b)

(e) unpredictable.

63. The current i_1 and i_2 through the resistors R_1 (= 10 Ω) and R_2 (= 30 Ω) in the circuit diagram with E_1 = 3 V, E_2 = 3 V and E_3 = 2 V are respectively



(a) 0.2 A, 0.1 A

(b) 0.4 A, 0.2 A

(c) 0.1 A, 0.2 A

(d) 0.2 A, 0.4 A (e) 0.4 A, 0.1 A.

64. An α-particle with a specific charge of 2.5×10^7 C kg^{-1} moves with a speed of 2×10^5 ms^{-1} in a perpendicular magnetic field of 0.05 T. Then the radius of the circular path described by it is

(a) 8 cm (b) 4 cm (c) 16 cm (d) 2 cm

(e) 32 cm.

65. A cyclotron can be used to accelerate

(a) α-particles (b) β-particles

(c) neutrons (d) neutrino

(e) positron.

66. The magnitude of the earth's magnetic field at a place is B_0 and the angle of dip is δ. A horizontal conductor of length l lying magnetic north-south moves eastwards with a velocity v. The emf induced across the conductor is

(a) zero (b) $B_0 lv \sin\delta$

(c) $B_0 lv$ (d) $B_0 lv\cos\delta$

(e) $B_0 \sin\delta$.

67. A milliammeter of range 0-30 A has internal resistance of 20 Ω. The resistance to be connected in series to convert it into a voltmeter of maximum reading 3 V is

(a) 49 Ω (b) 80 Ω (c) 40 Ω (d) 30 Ω

(e) 50 Ω.

68. A straight conductor of length l carrying a current I, is bent in the form of a semi-circle. The magnetic field in tesla at the centre of the semi-circle is

(a) $\frac{\pi^2 I}{l} \times 10^{-7}$ (b) $\frac{\pi I}{l} \times 10^{-7}$

(c) $\frac{\pi I}{l^2} \times 10^{-7}$ (d) $\frac{\pi l^2}{I} \times 10^{-7}$

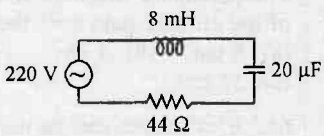
(e) $\frac{\pi^2 I}{l^2} \times 10^{-7}$

69. A coil having an inductance of 0.5 H carries a current which is uniformly varying from zero to 10 ampere in 2 second. The e.m.f. (in volts) generated in the coil is
(a) 10 (b) 5 (c) 2.5 (d) 1.25
(e) 0.25

70. If an alternating voltage is represented as $E = 141 \sin (628\, t)$, then the rms value of the voltage and the frequency are respectively
(a) 141 V, 628 Hz (b) 100 V, 50 Hz
(c) 100 V, 100 Hz (d) 141 V, 100 Hz
(e) 100 V, 314 Hz.

71. A step-down transformer is used on a 1000 V line to deliver 20 A at 120 V at the secondary coil. If the efficiency of the transformer is 80%, the current drawn from the line is
(a) 3 A (b) 30 A (c) 0.3 A (d) 2.4 A
(e) 24 A.

72. For the series LCR circuit shown in the figure, what is the resonance frequency and the amplitude of the current at the resonating frequency?



(a) 2500 rad s^{-1} and $5\sqrt{2}$ A
(b) 2500 rad s^{-1} and 5 A
(c) 2500 rad s^{-1} and $5/\sqrt{2}$ A
(d) 250 rad s^{-1} and $5\sqrt{2}$ A
(e) 25 rad s^{-1} and $5\sqrt{2}$ A

SOLUTIONS

1. **(a) :** $b > a > c$ or $a < b$ and $b > c$.

2. **(c) :** $\dfrac{\mu}{\mu_0} = \mu_r$; $\dfrac{\varepsilon}{\varepsilon_0} = K$

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} \text{ and } v = \frac{1}{\sqrt{\dfrac{\mu}{\mu_0} \cdot \dfrac{\varepsilon}{\varepsilon_0}}}$$

$$\therefore \quad v = \frac{c}{\sqrt{\mu_r \cdot K}}.$$

3. **(e)**

4. **(c) :** $\mu = 3/2$, $d = 4$ mm $= 4 \times 10^{-3}$ m

$$\mu = \frac{c}{v} \; ; \; v = \frac{d}{t}$$

or, $\mu = \dfrac{c \times t}{d} = \dfrac{3 \times 10^8 \times t}{4 \times 10^{-3}}$ or, $\dfrac{3}{2} = \dfrac{3 \times 10^8 \times t}{4 \times 10^{-3}}$

or, $t = \dfrac{3 \times 4 \times 10^{-3}}{2 \times 3 \times 10^8} = 2 \times 10^{-11}$ sec.

5. **(e) :** $\dfrac{1}{f} = \dfrac{1}{f_1} + \dfrac{1}{f_2} = \dfrac{1}{20} + \dfrac{1}{25} = \dfrac{9}{100}$

or, $P = 9$ D.

6. **(c) :** $|m| = \dfrac{\text{height of image}}{\text{height of object}}$ or, $|m| = \dfrac{v}{u}$.

7. **(c) :** $I_0 = A^2$
When one slit is closed, amplitude becomes half and intensity becomes 1/4th.
$\therefore \quad I = I_0/4$.

8. **(a) :** $\lambda = \dfrac{h}{mv}$

$$\frac{1}{2} m_\alpha (v_\alpha)^2 = \frac{1}{2} m_p (v_p)^2$$

$$\frac{1}{2} \cdot 4 m_p (v_\alpha)^2 = \frac{1}{2} m_p \cdot (v_p)^2$$

or, $\dfrac{v_\alpha}{v_p} = \dfrac{1}{2}$ or, $v_\alpha = \dfrac{v_p}{2}$

$$\lambda_\alpha = \frac{h}{m_\alpha \cdot v_\alpha} ; \; \lambda_p = \frac{h}{m_p \cdot v_p}$$

or, $\dfrac{\lambda_\alpha}{\lambda_p} = \dfrac{m_p v_p}{m_\alpha v_\alpha} = \dfrac{m_p}{4 m_p} \cdot 2 = \dfrac{1}{2}$.

9. **(e)**

10. **(b) :** $196 - 164 = 32$
$88 - 78 = 10$
$_{88}A^{196} \rightarrow {}_{78}B^{164}$
Then, $4\alpha + 0\beta = 32$ or, $\alpha = 8$
and $2\alpha - \beta = 10$ or, $16 - \beta = 10$. $\therefore \; \beta = 6$.

11. **(d) :** At $t = 0$, counts per second = 1600
At $t = 8$, counts per second = 100
In 8 sec, count rate reduces to $\dfrac{1}{16} = \dfrac{1}{2^4}$
Therefore, half life must be 2 sec. In 6 sec., the count rate will become $\dfrac{1600}{2^3} = 200$.

12. **(e)**

13. **(c) :** $\beta = \dfrac{\alpha}{1 - \alpha}$ or, $\beta - \beta\alpha = \alpha$

or, $\beta = \alpha(1 + \beta) \Rightarrow \alpha = \dfrac{\beta}{1 + \alpha}$.

14. **(e) :** $R = 5 \times 10^3\ \Omega$, $V = 50$ V

$$I = \frac{V}{R} = \frac{50}{(5 \times 10^3 + 50)} = \frac{1}{100 + 1} = \frac{1}{101} = 9.9 \text{ mA}.$$

15. (a) : $R_L = 5$ kΩ
Input resistance = 1 kΩ, $V_0 = 5$ mV, $\beta = 50$

$\beta = \frac{I_c}{I_b}$; Output voltage = 5kΩ × I_c

Input voltage = 5×10^{-3} V

$50 = \frac{I_c}{I_b}$ and $I_b = \frac{5\times10^{-3}}{1\times10^{-3}} = 5\times10^{-6}$ Ω.

$\therefore$ $I_c = 50 \times I_b = 50 \times 5 \times 10^{-6} = 250 \times 10^{-6}$

Now, voltage gain = $\frac{\text{output voltage}}{\text{input voltage}}$

$$= \frac{5\times10^3 \times 250\times10^{-6}}{5\times10^{-3}} = 250$$

16. (c) : $n_2 < n_1$

17. (a)

18. (e) : For resonance.

19. (a) : Covering range = $d = \sqrt{2hR}$

$= \sqrt{2\times100\times8\times10^6} = \sqrt{16\times10^8} = 4\times10^4 = 40$ km.

20. (e) : $\phi = \vec{B}\cdot\vec{A} = BA\cos\theta$

and $BqV = F$. $\therefore$ $B = \frac{F}{qV}$

$\therefore$ $\phi = \frac{F}{qV}A\cos\theta$

Dimensions = $\frac{[MLT^{-2}][L^2]}{[AT][LT^{-1}]}$

$\therefore$ Dimensional formula of ϕ will be $[M^1L^2A^{-1}T^{-2}]$ or, $[M^1L^2T^{-2}A^{-1}]$.

21. (e) : $A = \frac{a^2b^3}{c\sqrt{d}}$

$$\log A = 2\log a + 3\log b - \left(\log c + \frac{1}{2}\log d\right)$$

Differentiating both side

$$\frac{dA}{A} = \frac{2da}{a} + \frac{3db}{b} + \frac{dc}{c} + \frac{1}{2}\frac{dd}{d}$$

$= 2 \times 1\% + 3 \times 3\% + 2\% + \frac{1}{2}\times 2\%$

$= 2\% + 9\% + 2\% + 1\% = 14\%$.

22. (a) : Distance covered in 5th second

$$= u + \frac{a}{2}(2n-1) = 0 + \frac{a}{2}(10-1) = \frac{9a}{2}$$

Distance covered in 5 sec.,

$$S = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2}\times a \times 25 = \frac{25a}{2}$$

$\therefore$ Ratio = 9/25.

23. (d) : Change in velocity
Area = change in acceleration (a) × change in time (t)
= change in velocity.

24. (a) : $\vec{A} = 2\hat{i} - \hat{j} + \hat{k}$, $\vec{B} = 3\hat{i} + 2\hat{j} - 2\hat{k}$

$\vec{S} = \vec{B} - \vec{A} = (3\hat{i} + 2\hat{j} - 2\hat{k}) - (2\hat{i} - \hat{j} + \hat{k})$

$= \hat{i} + 3\hat{j} - 3\hat{k}$

$\vec{F}\cdot\vec{S} = (2\hat{i} + \hat{j} - \hat{k})\cdot(\hat{i} + 3\hat{j} - 3\hat{k}) = 2 + 3 + 3 = 8.$

25. (b) : Let h be the height of the tower, then from the laws of motion (under gravity),

$h = -ut_1 + \frac{1}{2}gt_1^2$ ... (i), when projected upward

$h = ut_2 + \frac{1}{2}gt_2^2$ ... (ii), when thrown downwards with velocity u.

Also, $h = \frac{1}{2}gt_3^2$ ... (iii), when released from rest.

From (i), $\frac{h}{t_1} = -u + \frac{1}{2}gt_1$ ... (iv)

From (ii), $\frac{h}{t_2} = u + \frac{1}{2}gt_2$ ... (v)

Adding (iv) and (v),

$$h\left(\frac{1}{t_1} + \frac{1}{t_2}\right) = \frac{1}{2}g(t_1 + t_2)$$

Putting the value in (iii), $t_3 = \sqrt{t_1t_2}$.

26. (d) : Horizontal range = $\frac{u^2\sin 2\theta}{g}$

Maximum height reached = $\frac{u^2\sin^2\theta}{2g}$

Ratio = $\frac{u^2\sin 2\theta \times 2g}{g\times u^2\sin^2\theta} = \frac{2\sin 2\theta}{\sin^2\theta}$

$= \frac{2\times1}{(1/\sqrt{2})^2} = \frac{2\times2}{1}$ ($\theta = 45°$)

= 4 : 1.

27. (d) : Length of second's hand = 3 cm = radius, $v = \omega r$.

and $\omega = \frac{2\pi}{T} = \frac{2\pi}{60} = \frac{\pi}{30} = 0.1047$ rad/sec.

$v = 0.1047 \times 3 = 0.00314$ m/s.

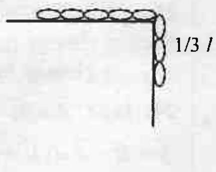
28. (a) : m = 150 g, v = 20 m/s, t = 0.1 s

$F = ma$

$a = v/t = 20/0.1 = 200$

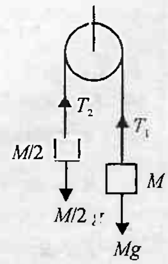
$$F = \frac{150}{1000}\times 200 = 30 \text{ N}.$$

29. (e) : For static friction,



$$\mu = \frac{F}{R} = \frac{\left(\frac{1}{3}l\right)\times M\times g}{\left(\frac{2}{3}l\right)M\times g} = \frac{1}{2}.$$

30. (a) : $Mg - T_1 = Ma$



$$T_2 - \frac{M}{2}g = \frac{M}{2}a$$

Solving, $\frac{M}{2}g = \frac{3M}{2}a \Rightarrow a = \frac{g}{3}$

$\therefore$ When the bigger mass is released, acceleration of the lighter mass will be $g/3$.

31. (a) : In elastic collision both momentum and kinetic energy are conserved.

32. (c) : $u = 0$, $S_n = \frac{1}{2}g(2n-1)$

Work done by the force of gravity in first second is

$$mgh - \frac{m}{2}g^2 = mg\left(h - \frac{g}{2}\right)$$

Work done in 2[nd] second is

$$mgh - \frac{3}{2}mg^2 \text{ or, } mg\left(h - \frac{3}{2}g\right)$$

Work done in third second is

$$mgh - \frac{5}{2}mg^2 \text{ or, } mg\left(h - \frac{5}{2}g\right)$$

Ratio of 1[st] and 2[nd] $= \frac{mg\left(h - \frac{g}{2}\right)}{mg\left(h - \frac{3g}{2}\right)} = 1 : 3.$

Ratio of 2[nd] and 3[rd] is $\frac{mg\left(h - \frac{3}{2}g\right)}{mg\left(h - \frac{5}{2}g\right)} = 3 : 5.$

$\therefore$ Ratio of 1[st] : 2[nd] : 3[rd] = 1 : 3 : 5.

33. (a) : Kinetic energy $= \frac{1}{2}mv^2$

Momentum $= mv = p$ or, kinetic energy $= p^2/2m$

or, $k_1 = \frac{p_1^2}{2m}$ or, $p_1 = \sqrt{2mk_1}$

$$2k_1 = k_2 \text{ or, } k_2 = \frac{p_2^2}{2m} \text{ or, } 2k_1 = \frac{p_2^2}{2m}$$

$\therefore$ $p_2 = \sqrt{4mk_1} = \sqrt{2}\sqrt{2mk_1} = \sqrt{2}p_1$

or, $p_2 = \sqrt{2}p_1$.

34. (b) : $x_{cm} = \frac{(M_P(0) + (M_Q)(PQ) + (M_R)(PR)}{M_P + M_Q + M_R}$

$$= \frac{1\times 0 + 1\times PQ + 1\times PR}{1+1+1} = \frac{PQ + PR}{3}.$$

35. (e) : Moment of inertia of uniform rod $= \frac{ML^2}{12}$

Now at a distance $L/4$, the moment of inertia will be

$$\frac{ML^2}{12} + M\left(\frac{L}{4}\right)^2 = \frac{ML^2}{12} + \frac{ML^2}{16} = \frac{ML^2}{4}\left(\frac{1}{3} + \frac{1}{4}\right)$$

$$= \frac{ML^2}{4}\left(\frac{7}{12}\right) = \frac{7ML^2}{48}.$$

36. (b) : Kinetic energy of rotation = 40% of K.E. of translation.

Kinetic energy of rotation $= \frac{1}{2}I\omega^2 = \frac{1}{2}mk^2 \times \frac{v^2}{R^2}$

Kinetic energy of translation $= \frac{1}{2}mv^2$

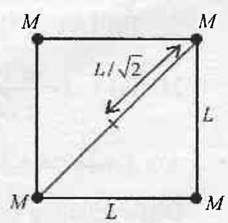
or, $\frac{1}{2}mk^2\frac{v^2}{R^2} = \frac{40}{100}\times\frac{1}{2}mv^2$

or, $\frac{k^2}{R^2} = \frac{2}{5} \Rightarrow k^2 = \frac{2}{5}R^2$

Moment of inertia of a solid sphere about its diameter is $\frac{2}{5}MR^2$. $\therefore$ The body is a solid sphere.

37. (e)

38. (a) : Potential energy at the centre is $-4\sqrt{2}\,\frac{4M}{L}$



or, $-\sqrt{2\times 16}\,\frac{GM}{L}$

$$= -\sqrt{32}\,\frac{GM}{L}.$$

39. (c) : $F = \frac{Gm_1m_2}{(2R)^2} = \frac{G\times\frac{4}{3}\pi R^3\rho\times\frac{4}{3}\pi R^3\rho}{4R^2}$

$$= G\times\frac{4}{9}\times\pi^2\rho^2R^4$$

i.e. $F \propto R^4$.

40. (c) : $Y = \frac{\text{stress}}{\text{strain}} = \frac{F/A}{\Delta L/L}$

Dimensionally $\frac{\Delta L}{L} = 1.$

$\therefore$ Modulus of elasticity is dimensionally equivalent to stress.

41. (d) : Let the pressure at the given point inside the liquid be $(P_1 + P_{atm})$

and $P_2 = P$ = at. pressure = cms of Hg

or 76 × 13.6 cms of water

Now, $P_1V_1 = P_2V_2$

i.e. $(P_1+P)\frac{4}{3}\pi r_1^3 = P\times\frac{4}{3}\pi(2r_1)^3$ or, $P_1 = 7P$

As P is in cms of water, the depth of the lake is $7P$.

42. (e) : $\frac{P}{\rho g}+\frac{v^2}{2g}$ – constant (by Bernoulli's theorem)

$$\therefore \quad \frac{P_1}{\rho g}+\frac{1}{2}\frac{v_1^2}{g}=\frac{P_2}{\rho g}+\frac{1}{2}\frac{v_2^2}{g}$$

$$\text{or,} \quad \frac{4.5\times10^5}{\rho g}+\frac{1}{2}\times0=\frac{4\times10^5}{\rho g}+\frac{1}{2}\frac{v_2^2}{g}$$

$$\text{or,} \quad \frac{0.5\times10^5}{\rho g}=\frac{1}{2}\frac{v_2^2}{g} \Rightarrow \frac{1\times10^5}{\rho}=v_2^2$$

$$\text{or,} \quad \frac{1\times10^5}{1\times10^3}=v_2^2 \Rightarrow 100=v_2^2 \Rightarrow v_2=10.$$

43. (a) : We know terminal velocity = $2r^2\frac{(\rho-\rho_0)g}{9\eta}$

Here $g' = g/2$

$$\therefore \quad V=2r^2\frac{(\rho-\rho_0)g/2}{9\eta}=\frac{r^2(\rho-\rho_0)g}{9\eta}.$$

44. (b) : $\frac{T_2}{T_1}=\frac{\lambda m_1}{\lambda m_2} \Rightarrow \frac{3000}{2000}=\frac{\lambda m}{\lambda m_2}$

$$\therefore \quad \lambda m_2=\frac{2}{3}\lambda m.$$

45. (a) : $\frac{PV}{T}=nR=1\times2$ cal/mole/kelvin.

46. (a) : $\gamma=\frac{\Delta V}{V\cdot\Delta V} \Rightarrow \gamma=\frac{0.24}{100\times40}$ and $\alpha=\frac{\gamma}{3}$

$$\alpha=\frac{24\times10^{-5}}{4\times3}=\frac{24}{12}\times10^{-5}=2\times10^{-5} \text{ per °C.}$$

47. (c) : Heat gain = heat lost

$$C_A(16-12)=C_B(19-16) \Rightarrow \frac{C_A}{C_B}=\frac{3}{4}$$

and $C_B(23-19)=C_C(28-23) \Rightarrow \frac{C_B}{C_C}=\frac{5}{4}$

$$\Rightarrow \frac{C_A}{C_C}=\frac{15}{16}$$

If θ is the temperature when A and C are mixed then,

$C_A(\theta-12)=C_C(28-\theta)$

$\therefore \quad \frac{28-\theta}{\theta-12}=\frac{C_A}{C_C}=\frac{15}{16}$. Solving, θ = 20.2°C.

48. (d)

49. (b) : Total energy of a simple harmonic motion is given by $E=\frac{1}{2}m\omega^2a^2$

$$\frac{3E}{4}=\frac{1}{2}m\omega^2(a^2-x^2)$$

$$\text{or,} \quad \frac{3}{4}\left(\frac{1}{2}m\omega^2a^2\right)=\frac{1}{2}m\omega^2(a^2-x^2)$$

$$\text{or,} \quad \frac{3}{4}a^2=a^2-x^2 \quad \text{or,} \quad x^2=a^2-\frac{3}{4}a^2$$

$$\text{or,} \quad x^2=\frac{a^2}{4} \quad \text{or,} \quad x=\frac{a}{2}.$$

50. (c) : A = 2 cm

Magnitude of velocity from mean position = $\omega\sqrt{A^2-x^2}$

and acceleration = ω^2x

Now, $\omega^2x=\omega\sqrt{A^2-x^2}$ or, $\omega^2\cdot1=\omega\sqrt{4-1}$

or, $\omega=\sqrt{3}$.

$$\omega=\frac{2\pi}{3} \quad \text{or,} \quad T=\frac{2\pi}{\omega}=\frac{2\pi}{\sqrt{3}}.$$

51. (d) : $\upsilon=\frac{V}{4l_1}$ for closed organ pipe

$\upsilon=\frac{V}{2l_2}$ for open organ pipe

$$\Rightarrow \quad \frac{v}{4l_1}=\frac{v}{2l_2} \quad \text{or,} \quad \frac{2}{4}=\frac{l_1}{l_2} \Rightarrow \frac{l_1}{l_2}=\frac{1}{2}.$$

52. (d) : Number of waves per minute = 54

$\therefore$ Number of waves per second = 54/60

Now, $v=\upsilon\lambda$

$$\therefore \quad v=\frac{54}{60}\times10=9 \text{ m/s.}$$

53. (c) : $\upsilon_{24}=2\upsilon_1$

and $\upsilon_{24}-\upsilon_1=(n-1)$ number of beats/s = 23 × 6

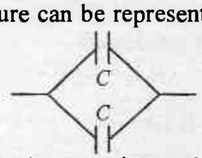
or, $2\upsilon_1-\upsilon_1=138$ or, $\upsilon_1=138$

$\therefore$ $\upsilon_2=\upsilon_1+6=138+6=144$ Hz.

54. (d)

55. (c) : According to Gauss's law.

56. (b) : The figure can be represented as



Now, the two capacitors are in parallel.

$\therefore$ $C_{eq}=C+C=2C$ and $C=\varepsilon_0A/d$.

$$\therefore \quad 2C=\frac{2\varepsilon_0A}{d}.$$

57. (b) : $V \propto \frac{1}{r}$

$\therefore \quad V_1 \propto \frac{1}{r_1}$ and $V_2 \propto \frac{1}{r_2}$

$\therefore \quad \frac{V_1}{V_2} = \frac{r_2}{r_1} \Rightarrow \frac{16}{V_2} = \frac{2r_1}{r_1} \Rightarrow V_2 = \frac{16}{2} = 8$ V.

58. (b) : $\frac{1}{2}\frac{q^2}{C_1{}^2} = \frac{1}{2}\frac{q^2}{C_2{}^2}$, but $C_2 = \frac{1}{2}C_1$

(There appears to be a misprint in the question paper. Values of q and C are given micro units but the answer is in milli units).

59. (d) : $R = 10\ \Omega$

Operating voltage = 100 V

Rate of heat developed, $H = I^2R$

And $I = \frac{V}{R} = \frac{110}{10} = 11.$

$H = (11)^2 \times 10 = 1210$ W.

60. (b) : Temperature of cold junction = 0°C

Neutral temperature = 285°C

Inversion temperature = 570°C.

61. (b)

62. (b) : $\frac{P}{1/3} = \frac{Q}{1-(1/3)}$; $l = 1$m

or, $3P = \frac{3}{2}Q$ or, $P = \frac{Q}{2}$ ... (i)

When 6 Ω resistance is connected in series then the balance point shifted as

$\frac{P+6}{2/3} = \frac{Q}{1/3}$ or, $\frac{3(P+6)}{2} = 3Q$

or, $P + 6 = 2Q$ ... (ii)

From (i), $\frac{Q}{2} + 6 = 2Q$ or, $6 = 2Q - \frac{Q}{2} = \frac{3Q}{2}$

or, $Q = 4$. Then $P = 2$.

63. (a) : In the loop containing three cells

$R_1i_1 + E_1 - E_2 - E_3 = 0$

Then, $R_1i_1 + 3 - 3 - 2 = 0$ or, $R_1i_1 = 2$

$i_1 = 2/R_1 = -2/10$ or, $|i_1| = 0.2$ A.

In the loop containing single cell

$R_2i_2 + E_2 = 0$ or, $R_2i_2 = -E_2$

or, $i_2 = \frac{-E_2}{R_2} = \frac{-3}{30} = -0.1$ A . $\therefore$ $|i_i| = 0.1$ A.

64. (c) : $Bqv = \frac{mv^2}{r}$ or, $Bq = \frac{mv}{r}$ or, $r = \frac{v}{Bq/m}$

As $q/m = 2.5 \times 10^7$ kg^{-1}, $B = 0.051$, $v = 2 \times 10^5$ m/s

$\therefore \quad r = \frac{2\times10^5}{5\times10^{-2}\times2.5\times10^7} = \frac{2}{12.5} = \frac{20}{125}$

$= 0.16$ m = 16 cm.

65. (a) 66. (b)

67. (b) : $I_A = 30 \times 10^{-3}$ A, $R_A = 20\ \Omega$, $R = ?$

$V = I_A(R + R_A) \Rightarrow 3 = 30 \times 10^{-3}(20 + R)$

$\Rightarrow 0.1 \times 10^3 = 20 + R \Rightarrow R = 100 - 20 = 80\ \Omega$.

68. (a) : Magnetic field at the centre of the semicircle

$= \frac{\mu_0}{4\pi}\frac{\pi I}{r}$

Here $r = l/\pi$

$\therefore \quad B = \frac{\mu_0}{4\pi}\cdot\frac{\pi^2 I}{l} = 10^{-7} \times \frac{\pi^2 I}{l}$.

69. (c) : $L = 0.5$ H. $e = -L\frac{dI}{dt}$

$\therefore \quad |e| = \left|L\frac{dI}{dt}\right| = \frac{5}{10} \times \frac{10}{2} = 2.5$

70. (c) : $E = 141\sin(628t)$

$E = E_0\sin\omega t$

$\omega = 628 \Rightarrow 2\pi\upsilon = 628$

$\therefore \quad \upsilon = \frac{628}{2\pi} = \frac{628}{2\times3.14} = 100$ Hz

$V_{rms} = \frac{v_0}{\sqrt{2}} = \frac{E_0}{\sqrt{2}} = \frac{141}{1.41} = 100$ V.

71. (a) : Efficiency $= \frac{E_sI_s}{E_pI_p} \times 100$

or, $80 = \frac{120\times20}{1000\times I_p} \times 100 \Rightarrow I_p = 3$ A.

72. (b) : Resonance angular frequency,

$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{8\times10^{-3}\times20\times10^{-6}}}$

$\omega_0 = \frac{10^4}{\sqrt{16}} = \frac{100}{4} \times 10^2 = 2500$ rad/s.

$I = \sqrt{\left(\frac{V}{R}\right)^2 + \left(\omega CV - \frac{V}{\omega L}\right)^2}$

$I^2 = \left(\frac{220}{44}\right)^2 + \left(25\times10^2\times20\times10^{-6}\times220 - \frac{220}{25\times10^2\times8\times10^{-3}}\right)^2$

$I^2 = (5)^2 + (11 - 11)^2$ or, $I = \sqrt{5^2} = 5$.

■

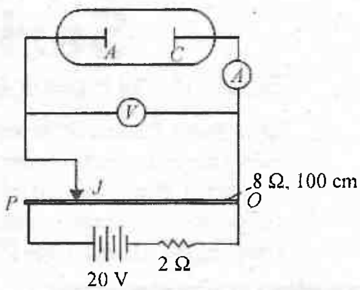
SAMPLE PAPER FOR IIT-JEE 2006

Based on *New pattern*

(For Q.NO. 1 to 45) Only one option is correct and there will be negative marking in these questions.

PASSAGE 1 : (Read the following passage and answer the questions numbered 1 to 5. They have only one correct option)

An experimental setup of verification of photoelectric effect is shown in the diagram. The voltage across the electrodes is measured with



the help of an ideal voltmeter, and which can be varied by moving jockey J on the potentiometer wire. The battery used in potentiometer circuit is of 20 V and its internal resistance is 2 Ω. The resistance of 100 cm long potentiometer wire is 8 Ω.

The photocurrent is measured with the help of an ideal ammeter. Two plates of potassium oxide of area 50 cm^2 at separation 0.5 mm are used in the vacuum tube. Photo current in the circuit is very small so we can treat potentiometer circuit an independent circuit.

The wavelengths of various colours is as follows :

	1	2	3	4	5	6
Light	Violet	Blue	Green	Yellow	Orange	Red
λ in Å	4000-4500	4500-5000	5000-5500	5500-6000	6000-6500	6500-7000

1. The number of electrons appeared on the surface of the cathode plate, when the jockey is connected at the end P of the potentiometer wire. Assume that no radiation is falling on the plates.

(a) 8.85×10^6 (b) 11.0625×10^9
(c) 8.85×10^9 (d) 0.

2. When radiation falls on the cathode plate a current of 2 μA is recorded in the ammeter. Assuming that the vacuum tube setup follows ohm's law, the equivalent resistance of vacuum tube operating in this case when jockey is at end P.

(a) $8 \times 10^8\ \Omega$ (b) $16 \times 10^6\ \Omega$
(c) $8 \times 10^6\ \Omega$ (d) $10 \times 10^6\ \Omega$

3. It is found that ammeter current remains unchanged (2 μA) even when the jockey is moved from the end P to the middle point of the potentiometer wire. Assuming all the incident photons eject electron and the power of the light incident is 4×10^{-6} W. Then the colour of the incident light is

(a) green (b) violet (c) red (d) orange

4. Which of the following colour may not give photoelectric effect from this cathode?

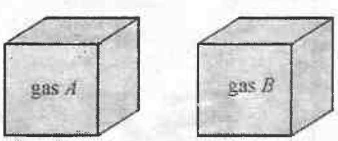
(a) green (b) violet (c) red (d) orange

5. When other light falls on the anode plate the ammeter reading remains zero till, jockey is moved from the end P to the middle point of the wire PO. Thereafter the deflection is recorded in the ammeter. The maximum kinetic energy of the emitted electron is

(a) 16 eV (b) 8 eV (c) 4 eV (d) 10 eV

Passage 2 : (Read the following passage and answer the questions numbered 6 to 10. They have only one correct option).

Two closed identical conducting containers are found in the laboratory of an old scientist. For



the verification of the gas some experiments are performed on the two boxes and the results are noted.

Experiment 1. When the two containers are weighed $W_A = 225$ g, $W_B = 160$ g and mass of evacuated container $W_C = 100$ g.

Experiment 2. When the two containers are given same amount of heat same temperature rise is recorded. The

Contributed by Deptt. of Physics. **Resonance**, Kota (Rajasthan)

pressure change found are $\Delta P_A = 2.5$ atm. $\Delta P_B = 1.5$ atm.

Required data for unknown gas :

Mono (molar mass	He 4 g	Ne 20 g	Ar 40 g	Kr 84 g	Xe 131 g	Rd 222 g
Dia (molar mass)	H_2 2 g	F_2 19 g	N_2 28 g	O_2 32 g	Cl_2 71 g	

6. Identify the type of gas filled in container A and B respectively.
(a) mono, mono (b) dia, dia
(c) mono, dia (d) dia, mono.

7. Identify the gas filled in the container A and B.
(a) N_2, Ne (b) He, H_2 (c) O_2, Ar (d) Ar, O_2

8. Total number of molecules in A (here N_A = Avagadro number)
(a) $\frac{125}{64}N_A$ (b) $3.125\ N_A$
(c) $\frac{125}{28}N_A$ (d) $32.25\ N_A$

9. The initial internal energy of the gas in container A, If the containers were at room temperature 300 K initially
(a) 1406.25 cal (b) 1000 cal
(c) 2812.5 cal (d) none of these

10. If the gases have initial temperature 300 K and they are mixed in an adiabatic container having the same volume as the previous containers. Now the temperature of the mixture is T and pressure is P. Then
(a) $P > P_A$, $T > 300$ K (b) $P > P_B$, $T = 300$ K
(c) $P < P_A$, $T = 300$ K (d) $P > P_A$, $T < 300$ K

Passage 3 : (Read the following passage and answer the questions numbered 11 to 15. They have only one correct option).

In a certain experiment to measure the ratio of charge and mass of elementary charged particles, a surprising result was obtained in which two particles moved in such a way that the distance between them remained constant always. It was also noticed that, this two particle system was isolated from all other particles and no force was acting on this system except the force between these two masses. After careful observation followed by intensive calculation it was deduced that velocity of these two particles was always opposite in direction and magnitude of velocity was 10^3 m/s and 2×10^3 m/s for first and second particle respectively and masses of these particles were 2×10^{-30} kg and 10^{-30} kg respectively. Distance between them came out to be 12 Å. (1 Å = 10^{-10} m)

11. Acceleration of the first particle was
(a) zero (b) 4×10^{16} m/s^2
(c) 2×10^{16} m/s^2 (d) 2.5×10^{15} m/s^2

12. Acceleration of second particle was
(a) 5×10^{15} m/s^2 (b) 4×10^{16} m/s^2
(c) 2×10^{16} m/s^2 (d) zero

13. If the first particle is stopped for a moment and then released. The velocity of centre of mass of the system just after the release will be
(a) $\frac{1}{3} \times 10^{-30}$ m/s (b) $\frac{1}{3} \times 10^3$ m/s
(c) $\frac{3}{2} \times 10^3$ m/s (d) none of these

14. Path of the two particles was
(a) intersecting straight lines
(b) parabolic (c) circular
(d) straight line w.r.t. each other

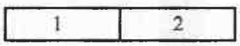
15. Angular velocity of the first particle was :
(a) 2.5×10^{12} rad/s (b) 4×10^{12} rad/s
(c) 4×10^{13} rad/s (d) zero

16. A one dimensional gas is a hypothetical gas with molecules that can move along only a single axis. The given table gives four situations, the velocities in metre per second of such a gas having four molecules. The plus and minus sign refer to the direction of the velocity along the axis. In which situation root-mean-square speed of the molecules is greatest?

Situation	Velocities			
A	−2	+3	−4	+5
B	+1	−3	+4	−6
C	+2	+3	+4	+5
D	+3	+3	−4	−5

(a) A (b) B (c) C (d) D

17. A composite bar of length $L = L_1 + L_2$ is made up from a rod of material 1 and of length L_1 attached to a rod of material 2 and of length L_2 as shown. If α_1 and α_2 are their respective coefficients of linear expansion, then equivalent coefficient of linear expansion for the composite rod is



(a) $\frac{\alpha_1 L_2 + \alpha_2 L_1}{L}$ (b) $\frac{\alpha_1 L_2 + \alpha_2 L_2}{L}$
(c) $\frac{\alpha_1 L_1 + \alpha_2 L_2}{L}$ (d) $\frac{\alpha_1\alpha_2(L_1 + L_2)}{(\alpha_1 L_1 + \alpha_2 L_2)}$

18. Some of the thermodynamic parameters are state variables while some are process variables. Some

grouping of the parameters are given. Choose the correct one.

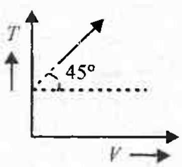
(a) state variables : temperature, no. of moles
process variables : internal energy, work done by the gas.

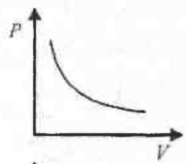
(b) state variables : volume, temperature
process variables : internal energy, work done by the gas.

(c) state variables : work done by the gas, heat rejected by the gas
process variables : temperature, volume.

(d) state variables : internal energy, volume
process variables : work done by the gas, heat absorbed by the gas.

19. The given curve represents the variation of temperature as a function of volume for one mole of an ideal gas. Which of the following curves best represents the variation of pressure as a function of volume?



(a)


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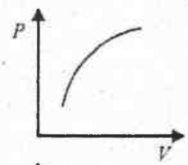

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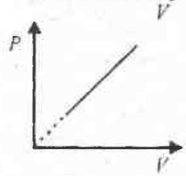
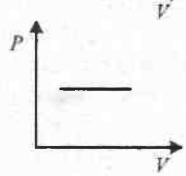


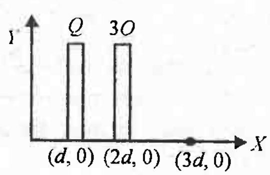
(d)


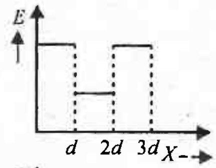
20. A uniform disc of radius R lies in the x-y plane, with its centre at origin. Its moment of inertia about z-axis is equal to its moment of inertia about line $y = x + c$. The value of c will be

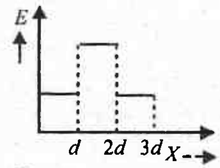
(a) $-\frac{R}{2}$ (b) $\pm\frac{R}{\sqrt{2}}$

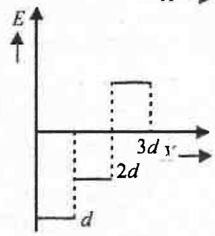
(c) $\frac{+R}{4}$ (d) $-R$

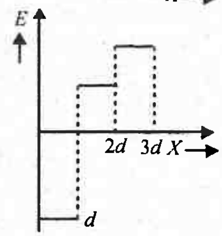
21. Two very large thin conducting plates having same cross-sectional area are placed as shown in figure they are carrying charges Q and $3Q$ respectively. The variation of electric field as a function at x (for $x = 0$ to $x = 3d$) will be best represented by



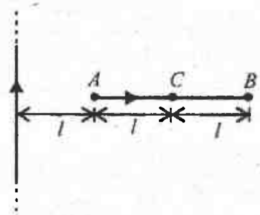
(a)


(b)


(c)


(d)


22. A current carrying rod AB is placed perpendicular to an infinitely long current carrying wire as shown in the figure. The point at which the conductor should be hinged so that it will not rotate.



(a) A (b) B

(c) C

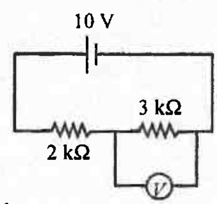
(d) some where between A and C

23. A steel rod of length 1 m is heated from 25°C to 75°C keeping its length constant. The longitudinal strain developed in the rod is (Given : Coefficient of linear expansion of steel = 12×10^{-6}/°C)

(a) 6×10^{-6} (b) -6×10^{-5}

(c) -6×10^{-4} (d) zero

24. In the circuit shown in figure, the resistance of voltmeter is 6 kΩ. The voltmeter reading will be

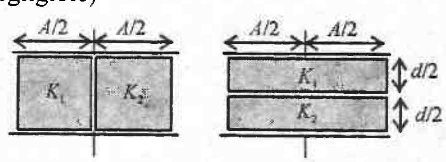


(a) 6 V

(b) 5 V

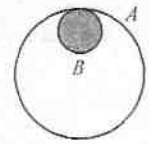
(c) 4 V (d) 3 V

25. In the arrangement shown in figure, dielectric constant $K_1 = 2$ and $K_2 = 3$. If the capacitance are C_1 and C_2 respectively, then C_1/C_2 will be (the gaps shown are negligible)



(a) 1 : 1 (b) 2 : 3 (c) 9 : 5 (d) 25 : 24

26. If a charged conductor B is so placed inside a hollow conductor that it touches the outer conductor. Then what will happen to its charge?



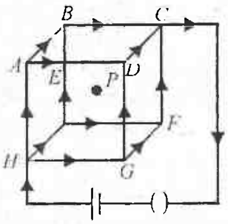
(a) The charge of B is transferred to A and comes on its outer surface.

(b) The entire charge of B is transferred to A and comes on its inner surface.

(c) A positive charge is induced on the outer surface of A.

(d) No charge will be transferred to A.

27. A steady current is set up in a cubic network composed of wires of equal resistance and length d as shown in figure. What is the magnetic field at the centre P due to the cubic network?



(a) $\frac{\mu_0}{4\pi}\frac{2I}{d}$ (b) $\frac{\mu_0}{4\pi}\frac{3I}{\sqrt{2}d}$

(c) 0 (d) $\frac{\mu_0}{4\pi}\frac{\theta\pi I}{d}$

28. In a step-up transformer the turns ratio is 10. If the frequency of the current in the primary coil is 50 Hz then the frequency of the current in the secondary coil will be

(a) 500 Hz (b) 5 Hz (c) 60 Hz (d) 50 Hz

29. A rectangular loop of sides of length l and b is placed in x–y plane. A uniform but time varying magnetic field of strength $\vec{B} = 20t\hat{i} + 10t^2\hat{j} + 50\hat{k}$ where t is time elapsed. The magnitude of induced e.m.f. at time t is

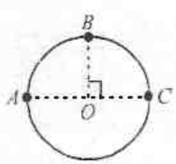
(a) 20 + 20 t (b) 20

(c) 20 t (d) zero

30. A train of mass M is moving on a circular track of radius R with constant speed V. The length of the train is half of the perimeter of the track. The linear momentum of the train will be

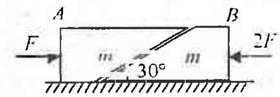
(a) zero (b) $\frac{2MV}{\pi}$ (c) MVR (d) MV.

31. Three particles A, B and C move in a circle of radius $r = 1/\pi$ m, in anticlockwise direction with speeds 1 m/s, 2.5 m/s and 2 m/s respectively. The initial positions of A, B and C are as shown in figure. The ratio of distance travelled by B and C by the instant A, B and C meet for the first time is



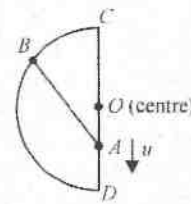
(a) 3 : 2 (b) 5 : 4 (c) 3 : 5 (d) 3 : 7

32. Two blocks A and B each of mass m are placed on a smooth horizontal surface. Two horizontal force F and $2F$ are applied on the 2 blocks A and B respectively as shown in figure. The block A does not slide on block B. Then the normal reaction acting between the two blocks is



(a) F (b) $F/2$ (c) $F/\sqrt{3}$ (d) $3F$.

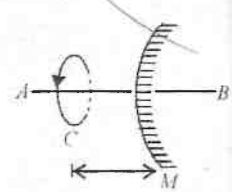
33. Two beads A and B move along a semicircular wire frame as shown in figure. The beads are connected by an inelastic string which always remains tight. At an instant the speed of A is u, $\angle BAC = 45°$ and $\angle BOC = 75°$, where O is the centre of the semicircular arc. The speed of bead B at that instant is



(a) $\sqrt{2}u$ (b) u

(c) $u/2\sqrt{2}$ (d) $\sqrt{2/3}\,u$

34. A particle revolves in clockwise direction (as seen from point A) in a circle C of radius 1 cm and completes one revolution in 2 sec. The axis of the circle and the principal axis of the mirror M coincide. Call it AB. The radius of curvature of the mirror is 20 cm. Then the direction of revolution (as seen from A) of the image of the particle and its speed is



(a) clockwise, 1.57 cm/s

(b) clockwise, 3.14 cm/s

(c) anticlockwise, 1.57 cm/s

(d) Anticlockwise, 3.14 cm/s

35. The wavelengths of K_α X-rays of two metals A and B are $\frac{4}{1875R}$ and $\frac{1}{675R}$ respectively, where R is Rydberg constant. The number of elements lying between A and B according to their atomic numbers is

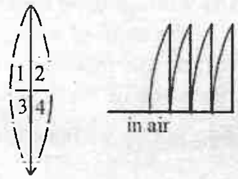
(a) 3 (b) 6

(c) 5 (d) 4

36. A proton and a neutron are both shot at 100 m/s

towards a $^{12}_{6}C$ nucleus. Which particle, if either, is more likely to be absorbed by the nucleus?
(a) the proton (b) the neutron
(c) both particles are about equally likely to be absorbed
(d) neither particle will be absorbed

37. The given lens is broken into four parts and rearranged as shown. If the initial focal length is f then after rearrangement the equivalent focal length is

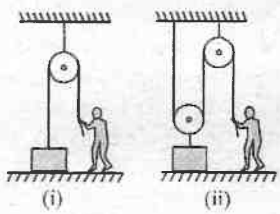


(a) f (b) $f/2$ (c) $f/4$ (d) $4f$.

38. A block of iron is kept at the bottom of a bucket full of water at 2°C. The water exerts bouyant force on the block. If the temperature of water is increased by 1°C the temperature of iron block also increases by 1°C. The bouyant force on the block by water
(a) will increase (b) will decrease
(c) will not change
(d) may decrease or increase depending on the values of their coefficient of expansion

39. An ice block at 0°C is dropped from height h above the ground. What should be the value of h so that it melts completely by the time it reaches the bottom assuming the loss of whole gravitational potential energy is used as heat by the ice? [Given : L_f = 80 cal/gm]
(a) 33.6 m (b) 33.6 km (c) 8 m (d) 8 km

40. In the figure shown, a person wants to raise a block lying on the ground to a height h. In both the cases if time required is same then in which case he has to exert more force. Assume pulleys and strings light.



(a) (i) (b) (ii)
(c) same in both (d) cannot be determined

Direction for questions (41 and 45) : Read each of the following numbered pairs of statement carefully one is an assertion (A) and the second is a possible reason (R). Mark your answers to question according to followings.
(a) If both assertion and the reason are true and the reason is an adequate explanation of assertion.
(b) If both assertion and the reason are true statements, but the reason does not explain the assertion
(c) If the assertion is a true statement but reason is a false statement
(d) If the assertion is false and reason is true statement.

41. Assertion : The binding energy of a satellite does not depend upon the mass of the satellite.
Reason : Binding energy is the negative value of total energy of satellite.

42. Assertion : Simple harmonic motion is not a uniformly accelerated motion.
Reason : Velocity is nonuniform in SHM.

43. Assertion : If two waves of same amplitude produce a resultant wave of same amplitude, then the phase difference between them will be 120°.
Reason : The resultant amplitude of two waves is equal to sum of amplitude of two waves.

44. Assertion : The D.C. and A.C. both can be measured by a hot wire instrument.
Reason : The hot wire instrument is based on the principle of magnetic effect of current.

45. Assertion : Although the surfaces of goggle lens are curved, it does not have any power.
Reason : In case of goggles, both the curved surfaces have equal radii of curvature and have centre of curvature on the same side.

One or more than one options may be correct (For Q.No. 46 to 55)

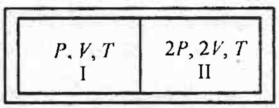
46. A solid sphere and a hollow sphere of the same material and of equal radii are heated to the same temperature
(a) both will emit equal amount of radiation per unit time in the beginning
(b) both will absorb equal amount of radiation from the surrounding in the beginning
(c) the initial rate of cooling will be the same for the two spheres
(d) the two spheres will have equal temperatures at any instant.

47. A particle of mass m moves along a curve $y = x^2$. When particle has x – co-ordinate as 1/2 and x-component of velocity as 4 m/s then.
(a) the position coordinate of particle are (1/2, 1/4)
(b) the velocity of particle will be along the line $4x - 4y - 1 = 0$.
(c) the magnitude of velocity at that instant is $4\sqrt{2}$ m/s
(d) the magnitude of angular momentum of particle about origin at that position is 0.

48. An electron makes a transition from $n = 2$ to $n = 1$ state in a hydrogen like atom.
(a) magnetic field at the site of nucleus is decreased by 16 times.
(b) magnetic field at the site of nucleus is increased by 32 times
(c) angular momentum of electron is changed
(d) none of these

49. The half life period of a radioactive substance is 20 days. If its initial concentration is doubled then the half-life period will becomes
(a) double (b) half
(c) four times (d) remains same

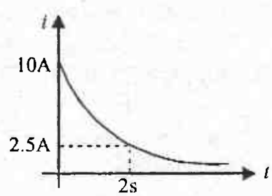
50. A partition divides a container having insulated walls into two compartments I and II.



The same gas fills the two compartments whose initial parameters are given. The partition is a conducting wall which can move freely without friction. Which of the following statements is/are correct, with reference to the final equilibrium position?
(a) The pressure in the two compartments are equal.
(b) Volume of compartment I is $3V/5$
(c) Volume of compartment II is $12V/5$
(d) Final pressure in compartment I is $5P/3$.

51. The rate of heat energy emitted by a body at an instant depends upon
(a) area of the surface
(b) difference of temperature between the surface and its surroundings
(c) nature of the surface (d) none of these

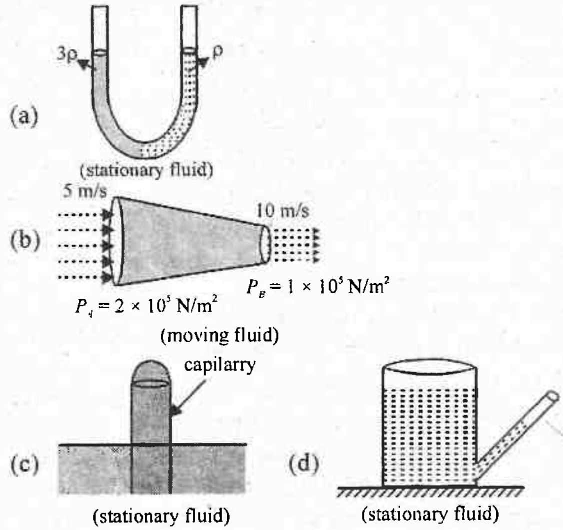
52. The figure shows, a graph of the current in a discharging circuit of a capacitor through a resistor of resistance 10 Ω.



(a) The initial potential difference across the capacitor is 100 volt.
(b) The capacitance of the capacitor is $\frac{1}{10\ln 2}$F
(c) The total heat produced in the circuit will be $\frac{500}{\ln 2}$ joules
(d) The thermal power in the resistor will decrease with a time constant $\frac{1}{2\ln 2}$ second

53. In series LCR circuit voltage drop across resistance is 8 volt, across inductor is 6 volt and across capacitor is 12 volt. Then
(a) voltage of the source will be leading current in the circuit
(b) voltage drop across each element will be less than the applied voltage
(c) power factor of circuit will be 4/3
(d) none of these

54. Which of the following is not possible ?



55. In which of the following cases potential energy increases?
(a) a spring is compressed from its natural length
(b) two opposite charges are brought near each other
(c) a body is taken away against gravitational force.
(d) air bubble rises up in water.

ANSWERS

1. (d)	2. (c)	3. (d)	4. (c)	5. (b)
6. (c)	7. (d)	8. (d)	9. (c)	10. (b)
11. (d)	12. (a)	13. (c)	14. (c)	15. (a)
16. (b)	17. (c)	18. (d)	19. (a)	20. (b)
21. (c)	22. (d)	23. (c)	24. (b)	25. (d)
26. (a)	27. (c)	28. (d)	29. (d)	30. (b)
31. (b)	32. (d)	33. (a)	34. (a)	35. (d)
36. (b)	37. (b)	38. (a)	39. (b)	40. (a)
41. (d)	42. (c)	43. (c)	44. (c)	45. (a)
46. (a, b)	47. (a, b, c)		48. (b, c)	49. (d)
50. (a, b, c, d)		51. (a, c)	52. (a, b, c, d)	
53. (d)	54. (a, c, d)		55. (a, c)	

Note : For detailed solutions please log on to our website www.resonance.ac.in

SOLVED PAPER

MANIPUR PMT - 2005

1. Find the correct statement.

(a) A potentiometer is a better device to determine e.m.f. of a cell than a voltmeter.
(b) Voltmeter is a better device to determine e.m.f. of a cell than a potentiometer.
(c) Both potentiometer and voltmeter is equally better device to determine e.m.f of a cell.
(d) e.m.f. of a cell cannot be determined by potentiometer.

2. An electromagnetic wave travelling in vacuum is given by $E_v = 30\cos[2\pi \times 10^8 t - 2\pi x/3]$, where E_v is in volt per meter, t in second and x in meter. Then the frequency and direction of propagation of the wave are

(a) 10^8 Hz, x direction (b) 10^8 Hz, y direction
(c) 30 Hz, x direction (d) 30 Hz, y direction.

3. $_{94}Pu^{246}$ emits in succession two β particles, three α-particles and three γ ray photons. The resultant isotope is

(a) $_{90}Th^{234}$ (b) $_{88}Ra^{234}$
(c) $_{92}U^{238}$ (d) $_{92}U^{236}$.

4. A 4 μF condenser is charged to 400 volt and then its plates are joined through a resistance. The heat produce in the resistance is

(a) 0.64 J (b) 0.32 J
(c) 0.16 J (d) 1.28 J.

5. Photoelectric current can be increased by

(a) increasing the intensity of light
(b) decreasing the intensity of light
(c) increasing the frequency of light
(d) decreasing the frequency of light.

6. After two hours 1/16 of the initial amount of a certain radioactive isotope remains un-decayed. The half life of the isotope is

(a) 15 min (b) 30 min
(c) 45 min (d) 1 hour.

7. In a cyclotron

(a) only electric field increases the energy of the charged particle
(b) only magnetic field increases the energy of the charged particle
(c) electric and magnetic field alternately increases the energy of the charged particle
(d) none of the above.

8. The equation of a body executing simple harmonic motion is given by $\pi\frac{d^2x}{dt^2} + gx = 0$. The time period of motion is

(a) $\left(\frac{\pi}{g}\right)^{1/2}$ (b) $\left(\frac{4\pi^3}{g}\right)^{1/2}$
(c) $\left(\frac{g}{4\pi^3}\right)^{1/2}$ (d) $\left(\frac{g}{\pi}\right)^{1/2}$

9. In a pressure cooker, cooking is fast because

(a) boiling point of water increases because of lower pressure
(b) boiling point of water increases because of increasing of pressure
(c) increase of latent heat of steam
(d) decrease of latent heat of steam.

10. The absorptive power of a perfectly black body is

(a) zero (b) one
(c) infinite (d) one hundred.

11. A galvanometer can be converted to an ammeter by connecting

(a) a high resistance in series with it
(b) a high resistance in parallel with it
(c) a low resistance in series with it
(d) a low resistance in parallel with it.

12. A tuning fork vibrates at 250 Hz. The length of the shortest closed organ pipe that will resonate with tuning fork is, if the speed of sound in air is 350 m/s

(a) 25 cm (b) 33 cm
(c) 60 cm (d) 35 cm.

13. Which of the following quantity remain constant in the motion of a planet in an elliptic orbit as seen from the sun?
(a) speed of the planet
(b) kinetic energy of the planet
(c) angular momentum of the planet
(d) velocity of the planet.

14. Water is normally used as a coolant liquid to take away heat from running engine because of its
(a) high density (b) high specific heat
(c) low specific heat
(d) high normal conductivity.

15. A circular disc is rotating at the rate of 600 rotations per minute, its angular velocity is
(a) 10 radian/sec (b) 60 radian/sec
(c) 31.4 radian/sec (d) 62.8 radian/sec.

16. A charged particle moving with velocity v enters a magnetic field in a direction perpendicular to the field and moves in a circular path of radius r. Then the time period of the particle
(a) increases with v
(b) decreases with v
(c) independent of v
(d) increases with v and r.

17. The refractive index of glass is 1.5. The speed of light in glass is
(a) 2×10^{10} m/s (b) 3×10^{10} m/s
(c) 2×10^{8} m/s (d) 3×10^{8} m/s.

18. Two sources of light are coherent if light waves coming from them are of same
(a) wavelength (b) velocity
(c) phase difference (d) frequency.

19. The speed of violet light and red light are exactly same
(a) in vacuum and air
(b) in vacuum but not in air
(c) in air but not in vacuum
(d) neither in vacuum nor in air.

20. Candela is the unit of
(a) luminous intensity (b) luminous efficiency
(c) luminous flux (d) illuminants.

21. The energy release by fission of a single uranium atom is 200 MeV. The number of fission per second required to produce 3.2 watt of power is
(a) 10^{7} (b) 10^{10}
(c) 10^{11} (d) 10^{12}.

22. The average size of a nucleus is of the order of
(a) 10^{-15} m (b) 10^{-10} m
(c) 10^{-8} m (d) 10^{-6} m.

23. Which of the following material is normally used as moderator in nuclear reactors?
(a) iron (b) germanium
(c) graphite (d) oxygen.

24. The half-life of Pa^{218} is 3 minutes. What fraction of 10 g sample of Pa^{218} will remain after 15 minutes?
(a) 1/5 (b) 1/2
(c) 1/125 (d) 1/32.

25. Which of the following transition in a hydrogen atom emits the photon of lowest frequency?
(a) $n = 2$ to $n = 1$ (b) $n = 4$ to $n = 2$
(c) $n = 4$ to $n = 3$ (d) $n = 3$ to $n = 1$.

ANSWERS

1. (a) : Potentiometer measures the e.m.f. of a cell more accurately as it is a null method.

2. (a) : $E_y = 30\cos\left[2\pi\times10^{8}t - \frac{2\pi x}{3}\right]$

Comparing it with the relation

$$E_y = 30\cos\left[2\pi\upsilon t - \frac{2\pi x}{\lambda}\right]$$

we get $\upsilon = 10^{8}$ Hz and direction of propagation of the wave is x direction.

3. (a) : An alpha particle has mass of 4 units and charge of +2 units. A β-particle has negligible mass and carries unit negative charge. A γ-particle carry no charge and massless particle. With emission of two β, 3α and 3γ particles, decrease in mass number 12 and decrease in charge number = 6 − 2 = 4.
∴ The resultant isotope is ${}_{90}Th^{234}$.

4. (b) : Heat produced in the resistance is equal to energy stored in capacitor

$$= \frac{1}{2}CV^2 = \frac{1}{2}\times4\times10^{-6}\times(400)^2 = 0.32 \text{ J}.$$

5. (a) : By increasing the intensity of the incident light, number of photons falling on a metal surface increases which will increase the number of photoelectrons thus the photoelectric current will increase.

6. **(b)** : $\frac{N}{N_0}=\left(\frac{1}{2}\right)^n$ or, $\frac{1}{16}=\left(\frac{1}{2}\right)^n$

$\Rightarrow$ $n = 4$.

i.e. $n=\frac{t}{T}=4$ or, $T=\frac{2}{4}=\frac{1}{2}$ hr = 30 min.

7. **(b)** : In a cyclotron energy of the charged particle is $\frac{1}{2}\frac{B^2q^2r^2}{m}$

i.e. $E=\frac{1}{2}\frac{B^2q^2r^2}{m}$ or, $E \propto B$

8. **(c)** : $\pi\frac{d^2x}{dt^2}=-gx$ or, $m\frac{d^2x}{dt^2}=-\frac{gmx}{\pi}$

Compare it with the relation, $m\frac{d^2x}{dt^2}=-kx$

we get $k = gm/\pi$

Time period of SHM = $T=2\pi\sqrt{\frac{m}{k}}$ or, $T=2\pi\sqrt{\frac{m\pi}{gm}}$

or, $T=\left[\frac{4\pi^{3/2}}{g}\right]^{1/2}$.

9. **(b)** : Increase of pressure increases the boiling point of water.

10. **(b)** : For a perfectly black body the absorptive power is unity.

11. **(d)** : To convert a galvanometer into an ammeter a low resistance is connected in parallel.

12. **(d)** : For a closed pipe, $n = v/4L$

or, $250=\frac{350}{4L}$ or, $L=\frac{350}{4\times250}=0.35$ m = 35 cm.

13. **(c)** : In a motion of a planet in an elliptic orbit as seen from the sun angular momentum of the planet remain constant.

14. **(b)** : Water has high specific heat. It means for a particular change in temperature it would draw maximum heat.

15. **(d)** : $\omega = 2\pi\upsilon$

$=2\times3.14\times\frac{600}{60}=62.8$ radian/sec.

16. **(c)** : Time of the particle = $\frac{2\pi m}{Bq}$

i.e. it is independent of v.

17. **(c)** : $\mu=\frac{c}{v}$

i.e. $v=\frac{3\times10^8}{1.5}=2\times10^8$ m/s.

18. **(c)** : For coherent source wavelength is same and phase is also same or phase difference is constant.

19. **(a)** : For vacuum and air all colours have same speed.

20. **(a)** : The S.I. unit of luminous intensity is candela.

21. **(c)** : Number of fission per second

$$=\frac{3.2}{200\times10^6\times1.6\times10^{-19}}=10^{11}.$$

22. **(a)** : The size of a nucleus is the order of 1 fm *i.e.* 10^{-15} m.

23. **(c)** : Graphite is used as a moderator in nuclear reactors.

24. **(d)** : $\frac{N}{N_0}=\left(\frac{1}{2}\right)^{t/T}$

$\frac{N}{N_0}=\left(\frac{1}{2}\right)^{15/3}$ or, $\frac{N}{N_0}=\left(\frac{1}{2}\right)^5$

or, $\frac{N}{N_0}=\frac{1}{32}$.

25. **(c)** : The energy in the n^{th} state of a hydrogen atom is given by

$E_n=+\frac{E_1}{n^2}$, [where $E_1 = -13.6$ eV]

$\therefore$ $\Delta E=E_2-E_1=\frac{E_1}{n_2^2}-\frac{E_1}{n_1^2}=E_1\left[\frac{1}{n_2^2}-\frac{1}{n_1^2}\right]$.

(i) $n = 2$ to $n = 1$

$$\Delta E=E_1\left[\frac{1}{1^2}-\frac{1}{4^2}\right]=\frac{3}{4}E_1=0.75E_1$$

(ii) $n = 4$ to $n = 2$

$$\Delta E_1=E_1\left[\frac{1}{2^2}-\frac{1}{4^2}\right]=\frac{3}{16}E_1=0.1875E_1$$

(iii) $n = 4$ to $n = 3$

$$\Delta E=E_1\left[\frac{1}{4^2}-\frac{1}{3^2}\right]=\frac{7}{144}E_1=0.004E_1$$

(iv) $n = 3$ to $n = 2$

$$\Delta E=E_1\left[\frac{1}{2^2}-\frac{1}{3^2}\right]=E_1\left[\frac{1}{4}-\frac{1}{9}\right]$$

$$=\frac{8}{9}E_1=0.88E_1.$$

For $n = 4$ to $n = 3$, hydrogen atom emits a photon of lowest frequency.

■

AIIMS | CBSE | DPMT | AFMC | VMMC | EAMCET | WB-JEE | BHU | CMC

2006 Medical Entrance Exam

UP CPMT | CET Karnataka | Manipal PMT | JIPMER

Practice Test Paper

MP PMT | MGIMS | PMDT Bihar | PMT Haryana | Kerala PMT | Raj. PMT | TNPCEE

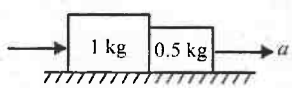
1. The unit of amplification factor is
(a) ohm (b) mho
(c) AV^{-1}
(d) a non-dimensional constant.

2. A rubber ball is dropped from a height of 5 metre on a plane where the acceleration due to gravity is not known. On bouncing, it rises to a height of 1.8 m. On bouncing the ball loses its velocity by a factor of
(a) 3/5 (b) 9/25
(c) 2/5 (d) 16/25.

3. A force F makes an angle 20° with another force F. The resultant of two forces is
(a) $F\cos 20°$ (b) $2F\cos 20°$
(c) $2F\cos 10°$ (d) $F\cos 10°$.

4. In the case of an oblique projectile, the velocity is perpendicular to acceleration
(a) once only (b) twice
(c) thrice (d) four times.

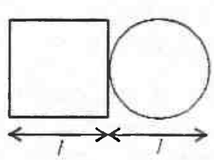
5. 1 kg block and 0.5 kg block move together on a horizontal frictionless surface. Each block exerts a force of 6 N on the other. The blocks moves with a uniform acceleration of



(a) 3 ms^{-2} (b) 6 ms^{-2}
(c) 9 ms^{-2} (d) 12 ms^{-2}.

6. A 5 kg brick of dimensions 20 cm × 10 cm × 8 cm is lying on the largest base. It is now made to stand with length vertical. If $g = 10$ ms^{-2}, then the amount of work done is
(a) 3 J (b) 5 J
(c) 7 J (d) 9 J.

7. If the density of a material of a square plate and a circular plate shown in figure is same, the centre of mass of the composite system will be



(a) inside the square plate
(b) inside the circular plate
(c) at the point of contact
(d) outside the system.

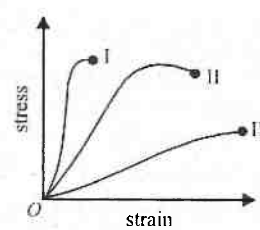
8. If a planet consists of a satellite whose mass and radius were both half that of the earth, the acceleration due to gravity at its surface would be

(g on planet = 9.8 ms^{-2})

(a) 4.9 ms^{-2} (b) 8.9 ms^{-2}
(c) 19.6 ms^{-2} (d) 29.4 ms^{-2}.

9. If R_m is the radius of moon's orbit round the earth, a_m the acceleration of moon towards the centre of earth, and R_e the radius of earth. Then a_m is equal to (if g is acceleration due to gravity on the surface of earth)
(a) $\left(\frac{R_e}{R_m}\right)g$ (b) $\left(\frac{R_m}{R_e}\right)g$
(c) $\left(\frac{R_m}{R_e}\right)^2 g$ (d) $\left(\frac{R_e}{R_m}\right)^2 g$

10. Figure shows stress/strain curves for three different materials taken to fracture. Which curve best shows the behaviour of a copper wire, and which one best shows the behaviour of a glass fibre?



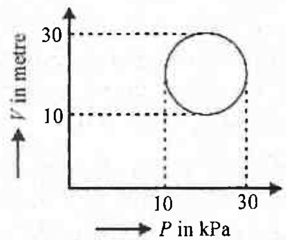
	Copper wire	Glass fibre
(a)	I	II
(b)	I	III
(c)	II	III
(d)	II	I

11. The mercury thread in a barometric tube stands at a height of 0.76 metre. If density of mercury is 13.6×10^3 kg m^{-3} and g is 9.8 ms^{-2}, then the atmospheric pressure in Nm^{-2} is

(a) 1.01×10^3 (b) 1.01×10^4
(c) 1.01×10^5 (d) 1.01×10^6.

12. Two different gases of molecular masses M_1 and M_2 are at the same temperature. What is the ratio of their mean square speeds?
(a) M_1/M_2 (b) M_2/M_1
(c) $\sqrt{M_1/M_2}$ (d) $\sqrt{M_2/M_1}$.

13. Heat energy absorbed by a system in going through a cyclic process shown in figure is



(a) $10^7 \pi$ J
(b) $10^4 \pi$ J
(c) $10^{-} \pi$ J
(d) $10^{-3} \pi$ J.

14. An object is at temperature of 400°C. At what approximate temperature would it radiate energy twice as first? The temperature of surroundings may be assumed to be negligible?
(a) 200°C (b) 200 K
(c) 800°C (d) 800 K.

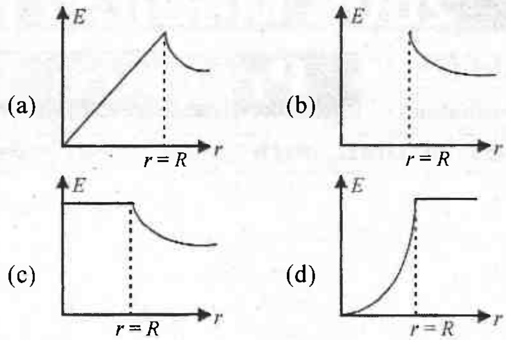
15. Consider a wave represented by $y = \cos(500t - 70x)$ where y is in mm, x in m and t in s. Which of the following are true?
(a) the wave is a standing wave
(b) the speed of the wave is 50/7 ms^{-1}
(c) the frequency of oscillations is $500 \times 2\pi$ Hz
(d) none of these

16. A spring-mass system oscillates in a car. If the car accelerates on a horizontal road, the frequency of oscillation will
(a) increase (b) decrease
(c) remain the same (d) becomes zero.

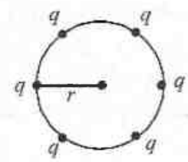
17. A particle moves in the X-Y plane according to the equation $\vec{r} = (\hat{i} + 2\hat{j})A\cos\omega t$. The motion of the particle is
(a) on a straight line (b) simple harmonic
(c) periodic (d) all of these.

18. When a charged particle is projected in a direction perpendicular to a uniform and static electric field, its path is
(a) a straight line (b) simple harmonic
(c) a parabola (d) all of these.

19. The graph between E and r for a conducting uniformly charged sphere of radius R is

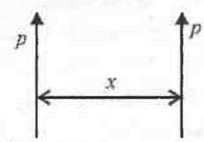


20. A point charge is surrounded symmetrically by six identical charges at distance r as shown in the figure. How much work is done by the forces of electrostatic repulsion when the point charge at the centre is removed at infinity?



(a) zero (b) $\frac{6q^2}{4\pi\varepsilon_0 r}$
(c) $\frac{q^2}{4\pi\varepsilon_0 r}$ (d) $\frac{12q^2}{4\pi\varepsilon_0 r}$

21. Two dipoles (dipole moment p) are placed as shown in figure. The force between two dipoles will be

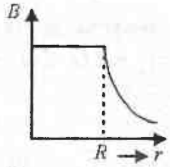


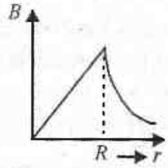
(a) $\frac{3kp^2}{2x^4}$ (b) $\frac{3kp^2}{x^4}$
(c) $\frac{3kp}{4x^4}$ (d) $\frac{3kp^2}{5x^4}$

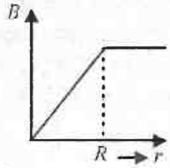
22. When the cells are connected in parallel
(a) the e.m.f. increases (b) the e.m.f. decreases
(c) the current capacity increases
(d) the current capacity decreases.

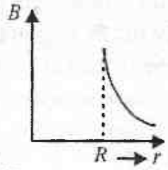
23. The potential difference between the terminals of a cell in an open circuit was 2.2 V. When it was measured across a resistor of 5 Ω it was found to be 1.8 V. The internal resistance of the cell is
(a) 10/9 Ω (b) 9/10 Ω
(c) 12/7 Ω (d) 7/12 Ω.

24. A long metallic cylinder of radius R has a current i flowing through it. The magnetic induction B will vary with distance from the centre as shown in the figure

A. 

B. 

C. 

D. 

(a) A (b) B
(c) C (d) D.

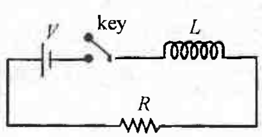
25. A proton is released from the origin at a place where fields $\vec{E}$ and $\vec{B}$ exist along –ve Y-axis and –ve Z-axis respectively. Find the displacement of the proton, when its velocity becomes perpendicular to the electric field for the first time, along Y-axis

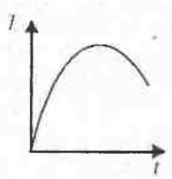
(a) $\frac{2Em}{eB^2}$ (b) $\frac{-2Em}{eB^2}$
(c) $\frac{Em}{eB^2}$ (d) $-\frac{Em}{eB^2}$

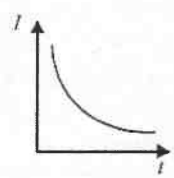
26. A proton (mass m and charge $+e$) and α-particle (mass $4m$ and charge +2e) are projected with the same kinetic energy at right angles to a uniform magnetic field. Which one of the following statements will be true?

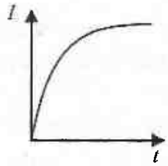
(a) the α-particle will be bent in a circular path with a smaller radius than proton
(b) the radius of the path of α-particle will be greater than that of proton
(c) radius of the paths of both the particles will be the same
(d) both will go through the magnetic field in the straight line.

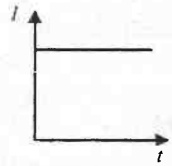
27. In the circuit shown in figure, the key is pressed at time $t = 0$. Which graph in figure shows the variation of current I with time t?



(a) 

(b) 

(c) 

(d) 

28. Lenz's law is a consequence of the law of conservation of

(a) charge (b) mass
(c) energy (d) momentum.

29. In a series LCR circuit, at resonance, the

(a) total impedence is $L\omega - \frac{1}{C\omega}$
(b) total impendence is R
(d) voltage across C and L are in phase
(d) the voltage across C lags the source voltage by $\pi/2$.

30. A star is moving towards earth, then spectral lines are shifted towards

(a) blue (b) red
(c) green (d) infrared.

31. A diffraction pattern is obtained by using red light. If red light is replaced by blue light then

(a) bands become broader and farther apart
(b) bands disappear
(c) bands become narrow and crowded together
(d) no change in bands will takes place.

32. An air bubble in a glass slab ($\mu = 1.5$) is 5 cm deep when viewed from one face and 2 cm deep when viewed from the opposite face. The thickness of the slab is

(a) 7 cm (b) 10.5 cm
(c) 7.5 cm (d) 10 cm.

33. If refractive index of water is 4/3 and glass is 5/3, then critical angle so that light travelling from glass to water is completely reflected is

(a) $\sin^{-1}(4/5)$ (b) $\sin^{-1}(5/4)$
(c) $\sin^{-1}(3/5)$ (d) $\sin^{-1}(4/5)$.

34. In a photoemissive cell, speed of fastest electron is v when radiations of wavelength λ are incident on it. If incident wavelength is changes to thrice the earlier wavelength, speed of fastest emitted electron will be

(a) $v\left(\frac{3}{4}\right)^{1/4}$ (b) $v\left(\frac{4}{3}\right)^{1/2}$

(c) less than $v\left(\frac{3}{4}\right)^{1/2}$ (d) greater than $v\left(\frac{4}{3}\right)^{1/2}$.

35. If the momentum of a particle is doubled, then wavelength associated with the particle will be
(a) remains unchanged (b) half
(c) double (d) none of these.

36. The de-Broglie wavelength of an electron of speed 0.5 kms^{-1} is
(a) 1.5×10^{-6} m (b) 1.5×10^{-8} m
(c) 1.5×10^{-10} m (d) 1.5×10^{-12} m.

37. A proton and an α-particle are accelerated through the same potential difference. Ratio of de-Broglie wavelength of the proton to that of α-particle will be
(a) 2 : 1 (b) 1 : 2
(c) $2\sqrt{2}:1$ (d) $1:2\sqrt{2}$

38. Potential energy V of a pair of nucleons varies with their distance d as
(a) $V \propto d$
(b) V = constant for $d < 0$ and $V = 0$ for $d > d_0$ where d_0 is same fixed distance
(c) $V \propto 1/d$ (d) $V \propto d^{-2}$.

39. Binding energies per nucleon for Li-7 and He-4 are 5.60 MeV and 7.06 MeV respectively. Then energy of the reaction : $Li^7 + H^1 \rightarrow He^4$ is
(a) 19.6 MeV (b) 17.3 MeV
(c) 8.4 MeV (d) 2.4 MeV.

40. Two radioactive materials X_1 and X_2 have decay constants $10/\lambda$ and $1/\lambda$ respectively. If initially, they have same number of nuclei, then ratio of the number of nuclei of X_1 to that of X_2 will be $1/e$, after a time
(a) $(1/9)\lambda$ (b) $(1/10)\lambda$
(c) $(1/11)\lambda$ (d) $(11/10)\lambda$.

41. When hydrogen atom is in its first excited level, its radius is
(a) half of the radius of hydrogen atom in its ground state
(b) same as radius of hydrogen atom in its ground state
(c) twice of the radius of hydrogen atom in it's ground state
(d) four times as the hydrogen atom in its ground state.

42. Uranium-235 is used as nuclear fuel in a nuclear reactor having power level 1 MW. Amount of fuel needed in one year will be (given : energy released per fission = 200 MeV)
(a) 87 gm (b) 103 gm
(c) 385 gm (d) 148.5 gm

43. If the shortest wavelength of Lyman series is 911.6 Å, then largest wavelength of the same series will be
(a) 1119.8 Å (b) 1215.5 Å
(c) 1376.8 Å (d) 1417.9 Å.

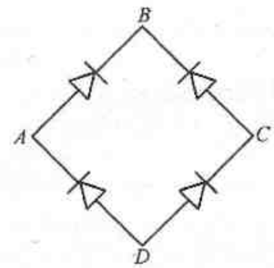
44. If ultraviolet light of wavelength 800 Å is allowed to fall on the hydrogen atom in its ground state, electron with kinetic energy 1.8 eV is liberated. If wavelength of the incident radiations is changed to 700 Å, then Planck's constant = 6.57×10^{-34} J sec)
(a) 3.8 eV (b) 4.0 eV
(c) 4.8 eV (d) 6.0 eV.

45. A hole in P-type semiconductor is
(a) missing atom (b) a missing electron
(c) a donor level (d) an excess electron.

46. Truth table given below corresponds to
(a) AND gate
(b) OR gate
(c) NAND gate
(d) NOR gate.

Inputs		Output
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

47. In the figure given, input is across A and C and output is across B and D. Then output is
(a) zero
(b) Vi
(c) half wave rectified
(d) full wave rectified.



48. Which of the following is responsible for the flow of current in a conductor?
(a) positive ions (b) free electrons
(c) protons and holes (d) protons.

49. Current gain of a semiconductor device is $\alpha = \frac{I_C}{I_E}$ and $\beta = \frac{I_C}{I_B}$ then relation between α and β is
(a) $\beta = \frac{\alpha}{1+\alpha}$ (b) $\alpha = \frac{\beta}{1-\beta}$
(c) $\beta = \frac{\alpha}{1-\alpha}$ (d) none of these.

50. A combination of AND function and NOT function results in
(a) OR gates (b) inversion
(c) NAND gate (d) NOR gate.

SOLUTIONS

1. **(d)** : Since amplification factor is the ratio of output voltage and input voltage therefore it is a dimensionless constant.

2. **(c)** : Fractional loss in velocity = $\frac{v_1 - v_2}{v_1}$

$$= 1 - \frac{v_2}{v_1} = 1 - \sqrt{\frac{2g \times 1.8}{2g \times 5}} = 1 - \frac{3}{5} = \frac{2}{5}.$$

3. **(c)** : $R^2 = F^2 + F^2 + 2F^2\cos 20° = 2F^2(1 + \cos 20°)$
or $R^2 = 2F^2(1 + 2\cos^2 10° - 1) = 4F^2\cos^2 10°$
or, $R = 2F\cos 10°$.

4. **(a)** : At the highest point of trajectory, the velocity becomes horizontal. So, it is perpendicular to acceleration (which is directed vertically downwards).

5. **(d)** : $6 = 0.5a$ or, $a = \frac{6}{0.5}\ \text{ms}^{-2} = 12\ \text{ms}^{-2}$.

6. **(a)** : Initial height of C.G. = 4 cm
Final height of C.G. = 10 cm
Increase in height = 6 cm = 0.06 m
Work done = 5 × 10 × 0.06 J = 3 J.

7. **(a)** : If ρ is mass/area, then mass of square is $l^2\rho$.
Again mass of circular plate is $\frac{\pi l^2 \rho}{4}$. Clearly, the square plate is more massive than the circular plate.

8. **(c)** : $g' = \frac{G(M/2)}{(R/2)^2} = 2\frac{GM}{R^2}$
$g' = 2g = 2 \times 9.8\ \text{ms}^{-2} = 19.6\ \text{ms}^{-2}$.

9. **(d)** : $\frac{a_m}{g} = \frac{GM_e/R_m^2}{GM_e/R_e^2}$ or, $\frac{a_m}{g} = \frac{R_e^2}{R_m^2}$

or, $a_m = \left[\frac{R_e}{R_m}\right]^2 g$.

10. **(d)** : Copper is ductile and glass is brittle.

11. **(c)** : $P = 0.76 \times 13.6 \times 10^3 \times 9.8\ \text{N m}^{-2}$
$= 1.01 \times 10^5\ \text{Nm}^{-2}$.

12. **(b)** : $C \propto \frac{1}{\sqrt{M}}$ or, $C^2 \propto \frac{1}{M}$

13. **(c)** : Area = $\frac{\pi D^2}{4} = \frac{\pi \times 20 \times 20}{4}$ J = 100 πJ.

14. **(d)** : $\frac{2Q}{Q} = \left[\frac{T_2}{673}\right]^4$

15. **(b)** : Comparing with $y = a\cos(\omega t - kx)$
$\omega = 500$, $k = 70$

Speed of wave = $\frac{\omega}{k} = \frac{500}{70} = \frac{50}{7}\ \text{ms}^{-1}$.

16. **(c)** : The frequency of oscillation does not depend upon the effective value of acceleration due to gravity, in a spring-mass system.

17. **(a)**

18. **(c)** : In this case $\frac{dv_x}{dt} = \frac{qE}{m}$ and $\frac{dv_y}{dt} = 0$

This gives $\frac{dx}{dt} = v_x = \left(\frac{qE}{2m}\right)t^2$

and $\frac{dy}{dt} = v_y =$ constant

We obtain $x = \left(\frac{qE}{2m}\right)t^2$ and $y = (\text{constant}) \times t$

This gives y^2 = constant × x.
So, the path is parabola.

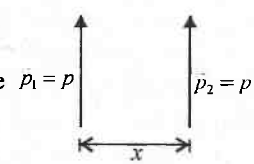
19. **(b)** : For conducting sphere, for $r < R$, $E = 0$.
However, for $r > R$, $E = kq/r^2$

where $k = \frac{1}{4\pi\varepsilon_0}$ and q is the charge on the sphere.

20. **(b)** : The potential energy of the point charge due to individual charges surrounding it is $U = \frac{q^2}{4\pi\varepsilon_0 r}$. Since the six charges are identical, the resultant potential energy of the point charge is $\frac{6q^2}{4\pi\varepsilon_0 r}$. Hence, the work done on moving the point charge to infinity is $6q^2/4\pi\varepsilon_0 r$.

21. **(b)** : Electric field at dipole 2 is due to 1 is

$E_{21} = \frac{1}{4\pi\varepsilon_0}\frac{P}{x^3}$ (opposite to $\vec{p}_1$)



Electric potential energy of the system is

$$U = -\vec{p}_2 \cdot \vec{E}_{21} = \frac{p^2}{4\pi\varepsilon_0 x^3}$$

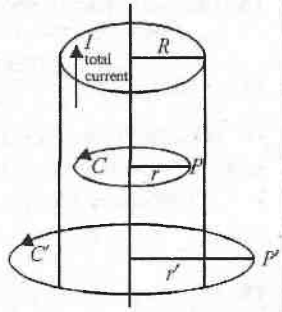
$$F = \frac{-dU}{dx} = -\left(\frac{p^2}{4\pi\varepsilon_0}\right)\left(-\frac{3}{x^4}\right) = \frac{3}{4}\frac{p^2}{\pi\varepsilon_0 x^4} = \frac{3kp^2}{x^4}.$$

Positive sign of F indicates that there is repulsion between the dipoles.

22. **(c)** : The current capacity increases when cells are connected in parallel.

23. **(a)** : $r = \left(\frac{E - V}{V}\right)R = \left(\frac{2.2 - 1.8}{1.8}\right)5 = \frac{10}{9}\ \Omega$.

24. (b) : In figure, if we want the magnetic field at an inside point P for a long metallic cylinder carrying current, I we consider a closed curve C as shown. We apply Ampere's circuital law here.



$$B(2\pi r) = \mu_0 \frac{I}{\pi R^2}\pi r^2$$

$$B = \left(\frac{\mu_0 I}{2\pi R^2}\right) r \quad . \quad B \propto r.$$

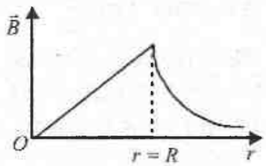
If we want the magnetic field at a point P' distant r' from the axis of the cylinder, then we again apply Ampere's circuital law for the curve C'. We obtain

$$B'(2\pi r') = \mu_0 I$$

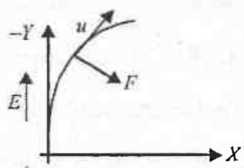
or, $$B' = \frac{\mu_0 I}{2\pi r'}.$$

$$B' \propto r'^{-1}$$

We now plot a graph for B-vs-r.



25. (b) : Let us take axes as shown in figure. According to the right-handed system, the Z-axis is upward in the figure and hence the magnetic field is shown downwards.



At any time, the velocity of the proton may be written as

$$\vec{u} = u_x\hat{i} + u_y\hat{j}$$

The electric and magnetic fields may be written as

$$E = -E\hat{j} \text{ and } \vec{B} = -B\hat{k} \text{ respectively.}$$

The force on the proton is

$$\vec{F} = e(\vec{E} + \vec{u}\times\vec{B}) = -eE\hat{j} - eB(u_y\hat{i} - u_x\hat{j})$$

Thus, $F_x = -eu_yB$ and $F_y = -e(E - u_xB)$

The components of the acceleration are

$$a_x = \frac{du_x}{dt} = -\frac{eB}{m}u_y \quad \text{... (i)}$$

and $$a_y = \frac{du_y}{dt} = -\frac{e}{m}(E - u_xB) \quad \text{... (ii)}$$

We have, $$\frac{d^2y}{dt^2} = +\frac{eB}{m}\frac{du_x}{dt} = -\frac{eB}{m}\cdot\frac{eB}{m}u_y = -\omega^2 u_y$$

where $\omega = eB/m$ ... (iii)

This equation is similar to that for a simple harmonic motion. Thus,

$$u_y = A\sin(\omega t + \delta) \quad \text{... (iv)}$$

and hence, $$\frac{du_y}{dt} = A\omega\cos(\omega t + \delta) \quad \text{... (v)}$$

At $t = 0$, $u_x = 0$ and $\frac{du_y}{dt} = \frac{F_y}{m} = -\frac{eE}{m}$

Putting in (iv) and (v),

$$\delta = 0 \text{ and } A = -\frac{eE}{m\omega} = -\frac{E}{B}$$

Thus, $u_y = -\frac{E}{B}\sin\omega t$

The path of the proton will be perpendicular to the Y-axis when $u_y = 0$. This will be the case for the first time at t where

$$\sin\omega t = 0 \quad \text{or,} \quad \omega t = \pi \quad \text{or,} \quad t = \frac{\pi}{\omega} = \frac{\pi m}{eB}$$

Also, $u_y = \frac{dy}{dt} = -\frac{E}{B}\sin\omega t$

or, $$\int_0^y dy = -\frac{E}{B}\int_0^t \sin\omega t\,dt$$

or, $$y = \frac{E}{B\omega}(-1 + \cos\omega t)$$

At $t = \frac{\pi}{\omega}$, $y = \frac{E}{B\omega}(-1 + \cos\pi) = -\frac{E}{B\omega}$

Thus, the displacement along the Y-axis is

$$\frac{-2E}{B\omega} = \frac{-2Em}{BeB} = \frac{-2Em}{eB^2}.$$

26. (c) : $qvB = \frac{mv^2}{R}$; $E_K = \frac{1}{2}mv^2 = \frac{p^2}{2m}$

$$p = mv = \sqrt{2mE_K}\ ; \ R = \frac{mv}{qB} = \frac{\sqrt{2mE_K}}{qB}$$

Since E_K is same but $m_\alpha = 4m_p$, $q_\alpha = 2q_p$, we obtain

$$R_p = \frac{\sqrt{2m_pE_K}}{q_pB} \ ; \quad R_\alpha = \frac{\sqrt{2m_\alpha E}}{q_\alpha B} = \frac{\sqrt{2m_pE_K}}{q_pB}$$

Hence $R_p = R_\alpha$.

27. (c) : The current grows and then becomes maximum with the increase in time.

28. (c)

29. (b) : At resonance, a series LCR circuit is totally resistive.

30. (a) : When star moves towards earth, wavelength of the light coming from it decreases and spectral lines shift towards the blue side.

31. (c) : Band width $\propto$ wavelength

When we go from red colour to blue colour wavelength

decreases and hence band width decreases, *i.e.* bands become narrower.

32. (b) : Total apparent depth $y = 7$ cm
If thickness of the slab = real depth = x (say)
Then $\mu = x/y \Rightarrow x = y \cdot \mu = 7 \times 1.5 = 10.5$ cm.

33. (d) : ${}^{w}\mu_g = \frac{{}^{a}\mu_g}{{}^{a}\mu_w} = \frac{5/3}{4/3} = \frac{5}{4} = \frac{1}{\sin c}$

or, $\sin c = \frac{4}{5} \Rightarrow c = \sin^{-1}\left(\frac{4}{5}\right)$.

34. (c) : $\frac{1}{2}mv^2 = \frac{hc}{\lambda} - \phi$ ... (i)

and $\frac{1}{2}mv'^2 = \frac{hc}{3\lambda} - \phi$ ... (ii)

From (i) and (ii), provided $\frac{hc}{3\lambda} > \phi$
i.e. if photoelectrons are emitted.

35. (b) : As $\lambda = h/P$

$\therefore \quad \lambda' = \frac{h}{2P} = \frac{1}{2}\left(\frac{h}{P}\right) = \frac{1}{2}\lambda.$

36. (a) : $\lambda = \frac{h}{mv}$ or, $\lambda = \frac{6.6 \times 19^{-34}}{9.1 \times 10^{-31} \times 500}$
$\Rightarrow \lambda = 1.5 \times 10^{-6}$ m.

37. (c) : $\lambda_p = \frac{h}{\sqrt{(2m)\text{eV}}}$

$$\lambda_\alpha = \frac{h}{\sqrt{2(4m) \cdot 2\text{ eV}}} = \frac{h}{\sqrt{(16m)\text{eV}}}$$

$\therefore \quad \lambda_p : \lambda_\alpha = 2\sqrt{2} : 1$.

38. (c)

39. (b) : Binding energy of Li-7 = 5.6 × 7 = 39.2 MeV
Binding energy of He-4 = 7.06 × 4 = 28.2 MeV
Since the reaction is not balance, first balance the reaction then calculate the energy of the reaction.

$$Li^7 + H^1 \rightarrow {}_2He^4$$

Energy of the reaction = 2 × 28.24 – 39.2 = 17.3 MeV.

40. (a) : $N_1 = N_0 e^{-\lambda_1 t}$, $N_2 = N_0 e^{-\lambda_2 t}$

$$\frac{N_1}{N_2} = \frac{e^{-\lambda_1 t}}{e^{-\lambda_2 t}} = e^{-1}$$

$$\therefore \quad t = \frac{1}{\lambda_1 - \lambda_2} = \frac{1}{\frac{10}{\lambda} - \frac{1}{\lambda}} = \frac{\lambda}{9}.$$

41. (d) : In first excited state $n = 2$ and $r \propto n^2$.
i.e. radius becomes four times.

42. (c) : Power in 1 MW = 10^6 J/s
Total E per second = 10^6 J
Energy released per fission = 200 MeV
= $200 \times 1.6 \times 10 \times 10^6$ J = 3.2×10^{-11} J.
No. of fissions needed per second

$$= \frac{10^6}{3.2 \times 10^{-11}} = 3.125 \times 10^{16}.$$

No. of fissions needed in one year
= $3.125 \times 10^{16} \times 365 \times 24 \times 60 \times 60$
$\approx 9.86 \times 10^{23}$
$\therefore$ Number of nucleus involved in fission per year
= 9.86×10^{23}

$\therefore$ Mass required = $\frac{235}{6.02 \times 10^{23}} \times 9.86 \times 10^{23} \approx 385$ gm

43. (b) : $\frac{\lambda_l}{\lambda_s} = \frac{R\left(\frac{1}{1^2} - \frac{1}{\infty}\right)}{R\left(\frac{1}{1^2} - \frac{1}{2^2}\right)} = \frac{4}{3}$

$$\lambda_l = \frac{4}{3}\lambda_s = \frac{4}{3} \times 911.6 = 1215.5 \text{ Å}.$$

44. (b) : Let E_1 and E_2 be the kinetic energy of electrons for incident radiations of wavelength λ_1 and λ_2 respectively.

$E_1 = \frac{hc}{\lambda_1} - \phi$ ... (i)

$E_2 = \frac{hc}{\lambda_2} - \phi$ ... (ii)

Subtracting them, $E_2 - E_1 = \frac{hc}{\lambda_2} - \frac{hc}{\lambda_1}$

$$E_2 = E_1 + hc\left[\frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right]$$

$$E_2 = 1.8 + \frac{6.57 \times 10^{-34} \times 3 \times 10^8}{1.6 \times 10^{-19}}\left[\frac{1}{700 \times 10^{-10}} - \frac{1}{800 \times 10^{-10}}\right]$$

or, $E_2 = 1.8 + \frac{6.57 \times 10^{-34} \times 3 \times 10^8}{1.6 \times 10^{-19}}$
$[1.43 \times 10^7 - 1.25 \times 10^7]$

or, $E_2 = 1.8 + \frac{6.57 \times 10^{-34} \times 3 \times 10^8}{1.6 \times 10^{-19}} \times 0.18 \times 10^7$

or, $E_2 = 1.8 + 2.2 = 4.0$ eV.

45. (b) : Hole is deficiency of electron.

46. (b) : For OR gate, $Y = A + B$.

47. (d) **48. (b)** **49. (c)**

50. (c) : AND gate followed by NOT gate is NAND gate.

■

Practice Paper *for* IIT-JEE 2006

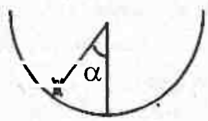
New pattern

Exam on 9th April

PART-A

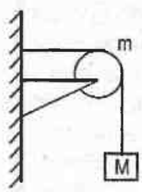
Note: For Question Numbers 1-15 only one answer is correct.

1. An insect crawls up a hemispherical surface very slowly (see the figure). The coefficient of friction between the insect and the surface is 1/3. If the line joining the center of the hemispherical surface to the insect makes an angle α with the vertical, the maximum possible value of α is given by



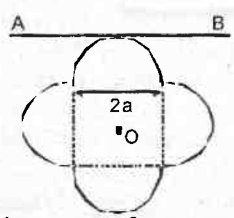
(a) $\cot\alpha = 3$ (b) $\tan\alpha = 3$
(c) $\sec\alpha = 3$ (d) $\operatorname{cosec}\alpha = 3$

2. A string of negligible mass going over a clamped pulley of mass m supports a block of mass M as shown in the figure. The force on the pulley by the clamp is given by



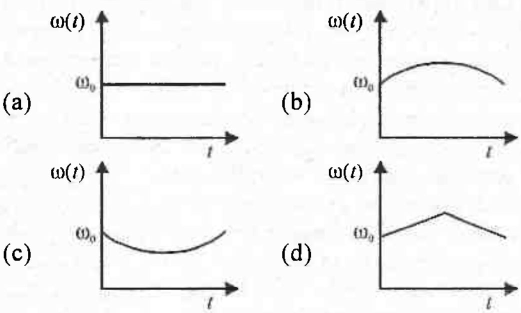
(a) $\sqrt{2}Mg$ (b) $\sqrt{2}mg$
(c) $\sqrt{(M+m)^2+m^2}g$ (d) $\sqrt{(M+m)^2+M^2}g$

3. A symmetrical lamina of mass M consists of a square shape with a semicircular section over the edge of the square as shown in figure. The side of the square is $2a$. The moment of inertia of the lamina about an axis through its centre of mass and perpendicular to the plane is $1.6\ Ma^2$. The moment of inertia of the lamina about the tangent AB in the plane of the lamina is

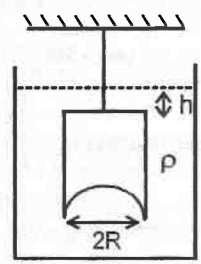


(a) $2.6\ Ma^2$ (b) $4.8\ Ma^2$
(c) $5.6\ Ma^2$ (d) $9.8\ Ma^2$

4. A circular platform is free to rotate in a horizontal plane about a vertical axis passing through its center. A tortoise is sitting at the edge of the platform. Now, the platform is given an angular velocity ω_0. When the tortoise moves along a chord of the platform with a constant velocity (with respect to the platform), the angular velocity of the platform $\omega(t)$ will vary with time t as

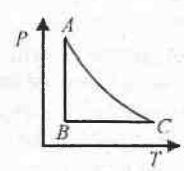


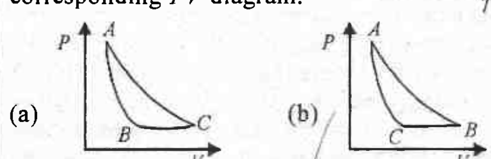
5. A hemispherical portion of radius R is removed from the bottom of a cylinder of radius R. The volume of the remaining cylinder is V and its mass is M. It is suspended by a string in a liquid of density ρ where it stays vertical. The upper surface of the cylinder is at a depth h below the liquid surface. The force on the bottom of the cylinder by the liquid is



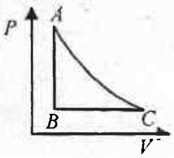
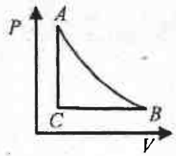
(a) Mg (b) $Mg - V\rho g$
(c) $Mg + \pi R^2 h\rho g$ (d) $\rho g(V + \pi R^2 h)$

6. The PT diagram for an ideal gas is shown in the figure, where AC is an adiabatic process, find the corresponding PV diagram.





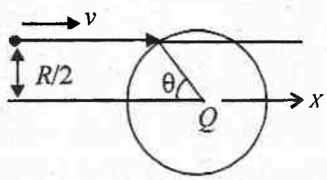
Contributed by : **Vidyarthi Academy**, 1/4, 1st Floor, Chandrodaya Society, Swastik Park, Opp. Swastik Chamber, Chembur, Mumbai, Ph.: 25222710

(c)  (d) 

7. A non-conducting ring of radius 0.5 carries a total charge of 1.11×10^{-10} C distributed non-uniformly on its circumference producing an electric field E everywhere in space. The value of the integral $\int_{\lambda=\infty}^{\lambda=0} -E \cdot d\lambda$ ($\lambda = 0$ being center of the ring) in volts is

(a) +2 V (b) –1 V (c) –2 V (d) zero

8. A particle of mass m strikes elastically with a horizontal disc of radius R, with a velocity v as shown in the figure. If the mass of the disc is equal to that of the particle and the surface of contact is smooth, the speed of the disc just after collision and its direction of motion with respect to initial direction of particle is



(a) $\frac{2v}{\sqrt{3}}$ along x (b) $\frac{\sqrt{3}}{2}v$, $\theta = 30°$

(c) $\frac{v}{2}$, 90° (d) $2v$, 45°.

9. Distance between the centers of two stars is $10a$. The masses of these stars are M and $16\,M$ and their radii a and $2a$ respectively. A body of mass m is fired straight from the surface of the larger star towards the smaller star. The minimum initial speed for the body to reach the surface of smaller star is

(a) $\frac{3}{2}\sqrt{\frac{GM}{a}}$ (b) $\frac{2}{3}\sqrt{\frac{5GM}{a}}$

(c) $\frac{3}{2}\sqrt{\frac{5GM}{a}}$ (d) $\frac{2}{3}\sqrt{\frac{GM}{a}}$

10. Two masses m and M are attached to a spring, which is kept in a stretched position with maximum extension x_0 and is released. Assuming the horizontal surface on which masses are placed to be frictionless, the time period for oscillation would be

(a) $2\pi\sqrt{\frac{Mm}{k(M+m)}}$ (b) $2\pi\sqrt{\frac{m}{k}}$

(c) $2\pi\sqrt{\frac{M}{k}}$ (d) $2\pi\sqrt{\frac{2Mm}{k(M+m)}}$

11. A wave equation is given by $y = A\cos(\omega t - kx)$, where symbols have their usual meanings. If v_p is the maximum particle velocity and v is the wave velocity of the wave then

(a) v_p can never be equal to v

(b) $v_p = v$ for $\lambda = 2\pi A$ (c) $v_p = v$ for $\lambda = A/2\pi$

(d) $v_p = v$ for $\lambda = A/\pi$.

12. A conducting sphere of radius R, carrying charge Q, lies inside an uncharged conducting shell of radius $2R$. When joined by a metal wire,

(a) 1/3 Q amount of charge will flow from the sphere to the shell

(b) 2/3 Q amount of charge will flow from the sphere to the shell

(c) Q/2 amount of charge will flow from the sphere to the shell

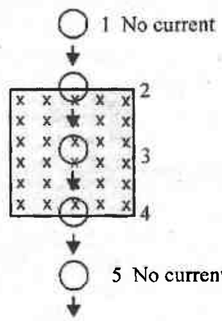
(d) $(Q^2/16\pi\varepsilon_0 R)$ amount of heat will be produced

13. A proton, a deuteron and an alpha particle are accelerated through potentials of V, $2V$ and $4V$ respectively. Their velocity will bear a ratio

(a) 1 : 1 : 1 (b) 1: $\sqrt{2}$: 1

(c) $\sqrt{2}$: 1: 1 (d) 1 : 1 : $\sqrt{2}$

14. Induced currents in position 2, 3, 4 are respectively



(a) clockwise, anticlockwise, clockwise

(b) anticlockwise, zero, anticlockwise

(c) anticlockwise, zero, clockwise

(d) anticlockwise, clockwise, clockwise

15. The work function for a substance is 4.0 eV. The longest wavelength of light that can cause photoelectron emission from this substance is approximately

(a) 540 nm (b) 400 nm

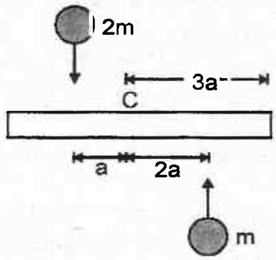
(c) 310 nm (d) 220 nm

PART-B

Note: For Question Numbers 16-30 one or more than one answer/s is/are correct.

16. An uniform bar length $6a$ and mass $8m$ lies on a smooth horizontal table. Two-point masses m and $2m$ moving in the same horizontal plane with speed $2v$ and v, respectively, strike the bar (as shown in figure) and stick to the bar after collision. Denoting angular velocity (about the center of mass), total energy and

center of mass velocity by ω, E and V_c respectively, we have after collision



(a) $V_c = 0$

(b) $\omega = \frac{3v}{5a}$

(c) $\omega = \frac{v}{5a}$

(d) $E = \frac{3mv^2}{5}$

17. A particle of mass m is projected with a velocity v making an angle of 45° with the horizontal. Magnitude of the angular momentum of the projectile about the point of projection when the particle is at its maximum height

(a) zero (b) $\frac{mv^3}{4\sqrt{2}g}$ (c) $\frac{mv^3}{\sqrt{2}g}$ (d) $m\sqrt{2gh^3}$

18. Two particles, each of mass m and charge q, are attached to the two ends of a light rigid rod of length $2R$. The rod is rotated at constant angular speed about a perpendicular axis passing through its centre. The ratio of the magnitudes of the magnetic moment of the system and its angular momentum about the centre of the rod is

(a) $q/2m$ (b) q/m (c) $2q/m$ (d) $q/\pi m$

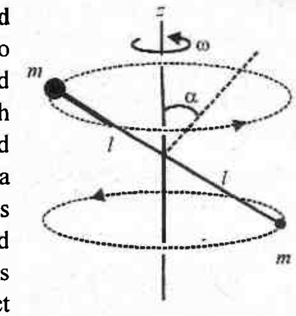
19. Three simple harmonic motions in the same direction having the same amplitude a and same period are superposed. If each differs in phase from the next by 45°, then

(a) the resultant amplitude is $(1 + \sqrt{2})a$
(b) the phase of the resultant motion relative to the first is 90°
(c) the energy associated with the resulting motion is $(3 + 2\sqrt{2})$ times the energy associated with any single motion
(d) the resulting motion is not simple harmonic

20. A wave is represented by the equation $y = A\sin(10 + 15\pi t + \pi/3)$, where x is in meters and t is in seconds. The expression represents

(a) a wave travelling in the positive x-direction with a velocity 1.5 m/s.
(b) a wave travelling in the negative x-direction with a velocity 1.5 m/s.
(c) a wave travelling in the negative x-direction having a wavelength 0.2 m.
(d) a wave travelling in the positive x-direction having a wavelength 0.2 m.

21. Consider a simple rigid body consisting of two particles of mass m separated by a massless rod of length $2l$. The midpoint of the rod is rigidly attached to a vertical axis which rotates at angular speed ω. The rod is skewed at angle α, as shown in the sketch. Neglect gravity. Angular momentum L of the system



(a) about z axis is $2ml^2\omega$
(b) about z axis is $2ml^2\omega\cos\alpha$
(c) $\bar{L}$ is constant (d) $\bar{L}$ is not constant

Note: Question Numbers 22-30 are passage based questions. Read the passages carefully and answer the following Multiple Choice Questions based on each passage. Each questions has one or more than one correct answer/s.

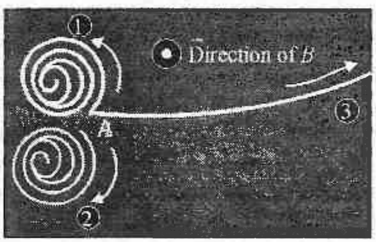
Passage 1: In the beginning, electricity and magnetism were entirely separate subjects. The one dealt with glass rods and cat's fur, pith balls, batteries, currents, electrolysis, and lightning; the other with bar magnets, iron filings, compass needles, and the North Pole. But in 1820 Oersted noticed that an electric current could deflect a magnetic compass needle. Soon afterward, Ampere correctly postulated that all magnetic phenomena are due to electric charges in motion. Then, in 1831, Faraday discovered that a moving magnet generates an electric current. By the time Maxwell and Lorentz put the finishing touches on the theory of electricity and magnetism were inextricably intertwined. They could no longer be regarded as separate subjects, but rather as two aspects of a single subject: electromagnetism. Faraday had speculated that light, too, is electrical in nature. Maxwell's theory provided spectacular justification for this hypothesis, and soon optics- the study of lenses, mirrors, prisms, interferences and diffraction was incorporated into electro-magnetism. Hertz, who presented the decisive experimental confirmation for Maxwell's theory in 1888, put it this way: "The connection between light and electricity is now established ...... In every flame, in every luminous particle, we see an electrical process ......Thus, the domain of electricity extends over the whole of nature. It even affects ourselves intimately: we perceive that we possess an electrical organ-the eye." By 1900, then, three great branches of physics: electricity, magnetism and optics, had merged into a single unified theory.

(And it was soon apparent that visible light represents only a tiny "window" in the vast spectrum of electromagnetic radiation, from radio through microwaves, infrared and ultraviolet, to X-rays and gamma rays.)

22. From passage we can conclude that
(a) we cannot treat electricity and magnetism separately
(b) we cannot treat optics and electromagnetism separately
(c) there is a single set of equations which can explain current electricity, magnetism and optics
(d) unification means single equation for all phenomenon

23. (a) According to Ampere a single moving charge can produce magnetic field
(b) Maxwell's theory united electricity and optics
(c) Discovery of electromagnetic radiation γ-rays, ultraviolet, visible, microwave etc. is unification theory.
(d) Discoveries by Oersted and Faraday are different physical phenomenon.

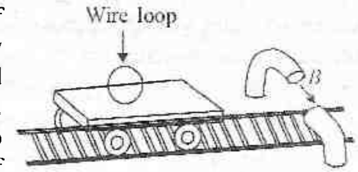
Passage 2: A bubble chamber contains a liquid that is just at the point of boiling. Tiny bubbles form along the trail of a high-energy particle passing through the liquid. The paths revealed in a cloud or bubble chamber can be photographed to provide a permanent record of the event. Figure shows the bubble-chamber tracks resulting from an event that begins at point A. At this point a gamma ray, which is emitted by certain radioactive substance and travels in from the left.



24. Particles 1, 2, 3 are
(a) proton, electron, proton
(b) electron, proton, proton
(c) electron (e^{-1}), positrion (e^{+}), electron (e^{-1})
(d) electron (e^{-1}), positrion (e^{+}), γ-ray

25. (a) tracks are spiral because of friction
(b) track are spiral because of collisions
(c) 3 has least velocity while 1, 2 have same velocity
(d) 3 has maximum velocity

Passage 3 : In its application to classical mechanics, the principle of relativity is hardly new; it was stated clearly by Galileo. Question: does it also apply to the laws of electro-dynamics? At first glance the answer would seem to be no. After all, a charge in motion produces a magnetic field, whereas a charge at rest does not. A charge carried along by the train would generate a magnetic field, but someone on the train, applying the laws of electrodynamics in that system, would predict no magnetic field. In fact, many of the equation of electrodynamics, starting with the Lorentz force law, make explicit reference to "the" velocity of the charge. It certainly appears, therefore, that electromagnetic theory presupposes the existence of a unique stationary reference frame, with respect to which all velocities are to be measured.



And yet there is an extraordinary coincidence that gives us pause. Suppose we mount a wire loop on a freight car, and have the train pass between the poles of a giant magnet. As the loop rides through the magnetic field, a motional emf is established; according to the flux rule $e = -(d\Phi/dt)$.
This emf, remember, is due to the magnetic force on charges in the wire loop, which are moving along with the train. On the other hand, if someone on the train naively applied the laws of electrodynamics in that system, what would the prediction be? No magnetic force, because the loop is at rest. But as the magnet flies by, the magnetic field in the freight car will change, and a changing magnetic field induces an electric field, by Faraday's law. The resulting electric force would generate an emf in the loop given by equation $e = -(d\Phi/dt)$.

26. Let person on train be A and on ground B.
(a) A is wrong but B is right
(b) A is right but B is wrong
(c) both are wrong
(d) they differ in interpretation but predictions are in agreement

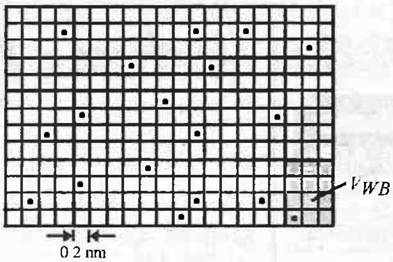
27. (a) A is correct in his interpretation if he is moving in inertial frame.
(b) B is correct in interpretation if he is stationary.
(c) in order to interpret correctly A and B must know in which frame they are.
(d) Interpretation tells us the frames in which they are.

Passage 4 : Air molecules are in continuous chaotic motion. What is the chance that all the air molecules

in a room could, for an instant, randomly fly into the wastepaper basket in the corner of the room? Is such a thing possible? Is it probable?

Perhaps surprisingly, the probability of this happening is far greater that the probability that all the air molecules in the room where you are sitting have the actual positions that they have right now. Although this may seem contrary to experience, we will prove it.

Let the volume of the room be V_R and that of wastepaper basket be V_{WB}. What is the chance that all n molecules in the room will randomly end up in the wastepaper? For all n molecules the probability is $(V_{WB}/V_R)^n$. This is exceedingly small number since $V_{WB}/V_R << 1$ and n is large. For a 0.3 -m^3 wastebasket and a 3000-m^3 room, the probability is $(10^{-4})^n$, where $n = 10^{24}$ a very small number indeed.



Can this possibility be larger than probability of specific distribution of molecules spread evenly throughout the room? Imagine the room divided into many small cells each equal to the smallest volume a molecule can be forced to occupy. This is an ill-defined number but for our purposes we will use the volume of a typical air molecule, roughly a cube 2×10^{-10} m on a side, or a volume of about 10^{-29} m. In our room of volume 3000 m^3, there are $N = 3000/10^{-29} = 3 \times 10^{32}$ cells. The probability that a single molecule is found in a specific cell is $1/N$. The probability that all n molecules are in their specific cells at any instant is $(1/N)^n = (1/3 \times 10^{-32})^n = 10^{-3.2 \times 10^{25}}$, or $10^{-2.8 \times 10^{25}}$ times the probability of all 10^{24} molecules being found in the wastebasket. It is incomparably smaller. The difference is that in the second calculation the molecular positions were exactly specified whereas in the first one they could be anywhere in the wastebasket. Had we specified the positions in the first case also, the probabilities would have been the same. For the same reason all lottery numbers are equally good: 01 02 03 04 05 06 is as likely as 23 18 07 12 37 15.

The distinction here is between the microstate of the system and its macrostate. A microstate is specified by giving a complete atomic description of each particle. A macrostate is specified by giving the values of macroscopic quantities such as pressure, temperature and volume, without regard to what is happening at the atomic level. We did not know, or care about, the precise locations of the individual molecules.

These two concepts are connected by the principle of equal probabilities: All possible microstates consistent with a given macrostate are equally likely.

28. (a) 1st calculation is for macrostate and 2nd for microstate.
(b) microstate corresponds to energy of atom or molecule.
(c) microstate corresponds to variables measured in lab.
(d) from the passage we conclude that macrostate can be achieved by probability distribution of atoms or molecules in microstates.

29. (a) For practical purposes pressure, volume etc. have a fixed value for given conditions.
(b) the probability that every molecule occupies a specific location is greater than probability that all molecules are in waste basket.
(c) the probability that every molecule occupies a specific location is less than probability that all molecules are in waste basket.
(d) If the volume of waste basket is doubled the probability of all the molecules are found in it is increased by a factor of $2^{10^{-24}}$.

30. In equilibrium state
(a) all the gas molecules are equally distributed in different microstates.
(b) most of the molecules are in most probable microstate.
(c) molecules are distributed in microstates as per temperature of each molecule.
(d) nothing can be said regarding distribution of molecules in microstates.

ANSWERS

1. (a)	2. (d)	3. (b)	4. (b)	5. (d)
6. (b)	7. (a)	8. (b)	9. (c)	10. (a)
11. (b)	12. (d)	13. (d)	14. (c)	15. (c)
16. (a, c, d)		17. (b, d)	18. (a)	
19. (a, c)	20. (b, c)	21. (d)	22. (c)	
23. (a, b, d)		24. (c)	25. (b, d)	26. (d)
27. (a, b, d)		28. (a, b, d)		
29. (a, c)	30. (b)			

SAMPLE PAPER FOR IIT-JEE 2006

Based on *New pattern*

(For Q.NO. 1 to 40) Only one option is correct and there will be negative marking in these questions)

(For Q.NO. 1 to 40) Only one option is correct and there will be negative marking in these questions.

1. The force exerted by a compression device is given by $F(x) = kx(x - l)$ for $0 < x < l$, where l is the maximum possible compression, x is the compression and k is a constant. The work required to compress the device by a distance d will be maximum when

(a) $d = l/4$ (b) $d = l/\sqrt{2}$
(c) $d = l/2$ (d) $d = l$.

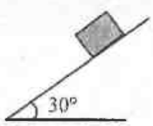
2. In a cricket match, the bowler running at velocity 1 m/s throws a ball (0.5 kg) at speed of 25 m/s after performing necessary bowling actions from a height 0.5 m from initial level in a time span of 1.5 seconds. The average power delivered to the ball by the bowler is

(a) 317/3 W (b) 634/3 W
(c) 635 W (d) 317.5 W

3. A particle is moving with velocity $v = \hat{i} + 3\hat{j}$ and it produces an electric field at a point given by $\vec{E} = 2\hat{k}$. It will produce magnetic field at that point equal to (all quantities are in S.I. units)

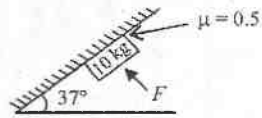
(a) $\dfrac{6\hat{i} - 2\hat{j}}{c^2}$ (b) $\dfrac{6\hat{i} + 2\hat{j}}{c^2}$
(c) zero
(d) cannot be determined from the given data.

4. Figure shows a block kept on a rough inclined plane. The maximum external force down the incline for which the block remains at rest is 2 N while the maximum external force up the incline for which the block is at rest is 10 N. The coefficient of static friction μ is



(a) $\sqrt{3}/2$ (b) $1/\sqrt{6}$
(c) $\sqrt{3}$ (d) $1/\sqrt{3}$

5. In the figure shown, the minimum force F to be applied perpendicular to the incline so that the block does not slide is



(a) 0 (b) 40 N
(c) 120 N (d) 200 N

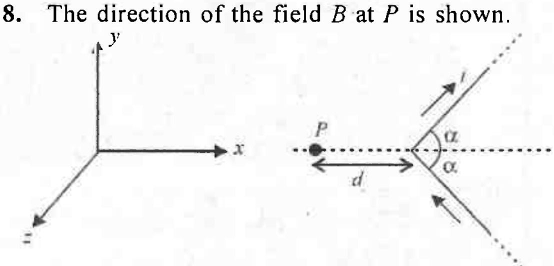
6. A particle is projected with a velocity u making an angle θ with the horizontal. The instantaneous power of the gravitational force

(a) varies linearly with time
(b) is constant throughout
(c) is negative for complete path
(d) none of the above

7. The energy that is dissipated during the braking process to stop a travelling car moving at 50 km/hr is η times that dissipated to stop the car when travelling at 100 km/hr. η is equal to

(a) 1/8 (b) 1/4
(c) less by a factor depending on the mass of the car
(d) 1/2

8. The direction of the field B at P is shown.



The V shaped wire is in x-y plane.

(a) along + x-axis (b) along + z-axis
(c) along $(-x)$–axis (d) along + y-axis

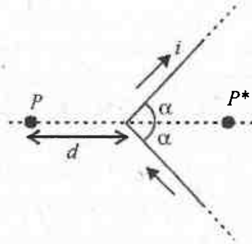
9. If the magnetic field at P can be written as $K\tan(\alpha/2)$ then K is [Refer to the figure of question no. 8]

Contributed by Deptt. of Physics, **Resonance**, Kota (Rajasthan)

(a) $\frac{\mu_0 I}{4\pi d}$ (b) $\frac{\mu_0 I}{2\pi d}$

(c) $\frac{\mu_0 I}{\pi d}$ (d) $\frac{2\mu_0 I}{\pi d}$

10. The direction of field B at a point P symmetric to P^* with respect to the vertex, *i.e.*, along the axis and the same distance d, but inside the V is along

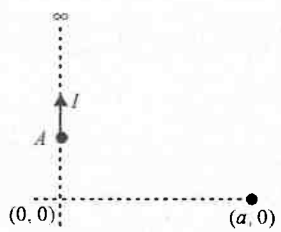


(a) positive z-axis
(b) negative x-axis
(c) negative z-axis (d) negative y-axis

11. A magnetic dipole $\vec{M} = (A\hat{i} + B\hat{j})$ J/Wb is placed in magnetic field. $\vec{B} = (Cx^2\hat{i} + Dy^2\hat{j})$ Wb in XY plane at $\vec{r} = (E\hat{i} + F\hat{j})$ m. Then force experienced by the bar magnet is

(a) $2ACE\hat{i} + 2BDF\hat{j}$ (N)
(b) $2ACE\hat{i}$ (N) (c) 0
(d) $ACE\hat{i} + BDF\hat{j}$ (N)

12. An infinitely long wire carrying current I is along Y axis such that its one end is at point A (0, b) while the wire extends upto $+\infty$. The magnitude of magnetic field strength at point (a, 0)



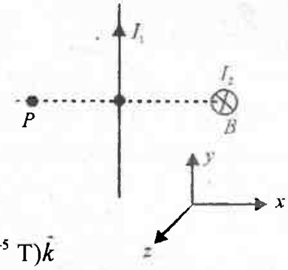
(a) $\frac{\mu_0 I}{4\pi a}\left(1+\frac{b}{\sqrt{a^2+b^2}}\right)$ (b) $\frac{\mu_0 I}{4\pi a}\left(1-\frac{b}{\sqrt{a^2+b^2}}\right)$

(c) $\frac{\mu_0 I}{4\pi a}\left(\frac{b}{\sqrt{a^2+b^2}}\right)$ (d) none of these.

13. Two observers moving with different velocities see that a point charge produces same magnetic field at the same point A. Their relative velocity must be parallel to $\vec{r}$ where $\vec{r}$ is the position vector of point A with respect to point charge. This statement is

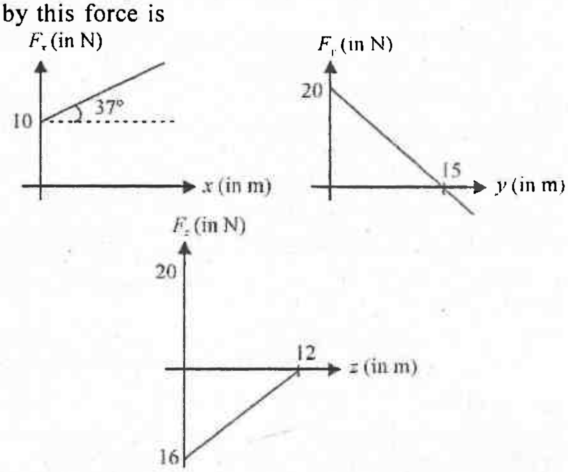
(a) true (b) false
(c) nothing can be said
(d) true only if the charge is moving perpendicular to the $\vec{r}$.

14. Two infinitely long linear conductors are arranged perpendicular to each other and are in mutually perpendicular planes as shown in figure. If $I_1 = 2$ A along the y-axis and $I_2 = 3$ A along $-$ve z-axis and $AP = AB = 1$ cm. The value of magnetic field strength $\vec{B}$ at P is



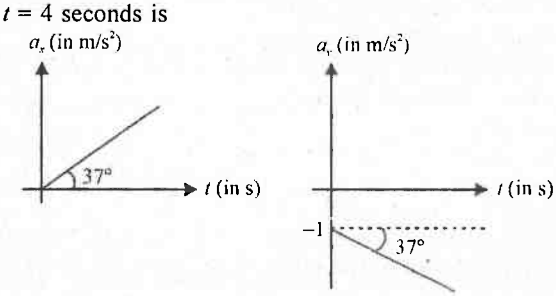
(a) $(3\times10^{-5}\text{ T})\hat{j} + (-4\times10^{-5}\text{ T})\hat{k}$
(b) $(3\times10^{-5}\text{ T})\hat{j} + (4\times10^{-5}\text{ T})\hat{k}$
(c) $(4\times10^{-5}\text{ T})\hat{j} + (3\times10^{-5}\text{ T})\hat{k}$
(d) $(-3\times10^{-5}\text{ T})\hat{j} + (4\times10^{-5}\text{ T})\hat{k}$

15. The components of a force acting on a particle are varying according to the graphs shown. When the particle moves from (0, 5, 12) to (4, 20, 0) then the work done by this force is



(a) 192 J (b) 400/3 J
(c) 0 (d) none of these

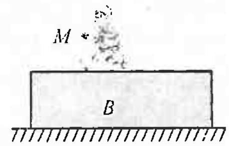
16. In the figure the variation of components of acceleration of a particle of mass 1 kg is shown with respect to time. The initial velocity of the particle is $\vec{u} = (-3\hat{i} + 4\hat{j})$ m/s. The total work done by the resultant force on the particle in time interval from t = 0 to t = 4 seconds is



(a) 22.5 J (b) 10 J
(c) 0 (d) none of these

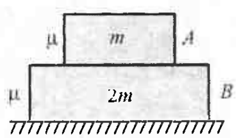
17. The potential energy function associated with the force $\vec{F} = 4xy\hat{i} + 2x^2\hat{j}$ is
(a) $U = -2x^2y$ (b) $U = -2x^2y$ + constant
(c) $U = 2x^2y$ + constant (d) not defined

18. As shown in the figure, M is a man of mass 60 kg standing on a block of mass 40 kg kept on ground. The coefficient of friction between the feet of the man and the block is 0.3 and that between B and the ground is 0.1. If the man accelerates with an acceleration 2 m/s^2 in the forward direction, then



(a) it is not possible
(b) B will move backwards with an acceleration 0.5 m/s^2
(c) B will not move
(d) B will move forward with an acceleration 0.5 m/s^2.

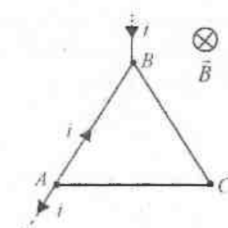
19. In the figure the block A of mass m is place on the block B of mass $2m$. B rests on the floor. The co-efficient of friction between A and B as well as that between the floor and B is μ. Both blocks are given the same initial velocity to the right. The acceleration of A with respect to B is



(a) zero (b) μg to the left
(c) μg to the right (d) 1/2 μg to the left

20. A heavy body of mass 25 kg is to be dragged along a horizontal plane ($\mu = 1/\sqrt{3}$). The least force required is
(a) 25 kgf (b) 2.5 kgf
(c) 12.5 kgf (d) $25/\sqrt{3}$ kgf.

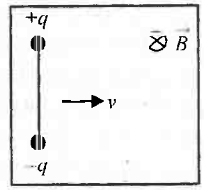
21. Figure shows an equilateral triangle ABC of side l carrying currents. placed in uniform magnetic field B. The magnitude of magnetic force on triangle is



(a) ilB
(b) $2ilB$
(c) $3ilB$ (d) zero.

22. A charge of magnitude 1 μC and mass 1 mg is attached to one end of a light string of length 2 m whose other end is fixed. The charge is given a velocity 1 m/s. There is a magnetic field of 1 T perpendicular to the plane of revolution of charge. The tension in string at that moment will be (Neglect gravity)
(a) 5×10^{-7} N (b) 15×10^{-7} N
(c) 10^{-6} N (d) zero

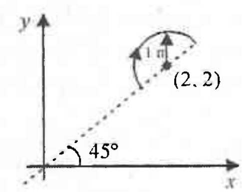
23. Two changes $+q$ and $-q$ are attached to the two ends of a light rod of length L, as shown in figure. The system is given a velocity v perpendicular to magnetic field $\vec{B}$. The magnetic force on the system of charges and magnitude of force on one charge by the rod, are respectively



(a) zero, zero (b) zero, qvB
(c) $2qvB$, 0 (d) $2qvB$, qvB

24. A neutral particle is at rest in a uniform magnetic field $\vec{B}$. At $t = 0$, particle decays into two particles each of mass m and one of them having charge q. Both of these move off in separate paths lying in plane perpendicular to $\vec{B}$. At later time, the particles collide. Then this time of collision is
(a) $\dfrac{\pi m}{qB}$ (b) $\dfrac{2\pi m}{qB}$
(c) $\dfrac{\pi m}{4qB}$ (d) they will never collide.

25. A uniform magnetic field $\vec{B} = (3\hat{i} + 4\hat{j} + \hat{k})$ exists in region of space. A semicircular wire of radius 1 m carrying current 1 A having its centre at (2, 2, 0) is placed in x-y plane as shown in figure. The force on semicircular wire will be

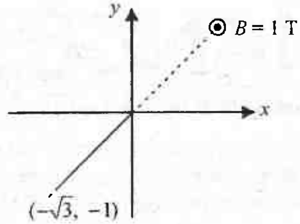


(a) $\sqrt{2}\,(\hat{i} + \hat{j} + \hat{k})$ (b) $\sqrt{2}\,(\hat{i} - \hat{j} + \hat{k})$
(c) $\sqrt{2}\,(\hat{i} + \hat{j} - \hat{k})$ (d) $\sqrt{2}\,(-\hat{i} + \hat{j} + \hat{k})$

26. There exists a uniform magnetic and electric field of magnitude 1 T and 1 V/m respectively along positive y-axis. A charged particle of mass 1 kg and of charge 1 C is having velocity 1 m/sec along x-axis and is at origin at $t = 0$. Then the co-ordinates of particle at time π seconds will be
(a) (0, 1, 2) (b) (0, $-\pi^2/2$, $-$ 2)
(c) (2, $\pi^2/2$, 2) (d) (0, $\pi^2/2$, 2)

27. A uniform magnetic field of magnitude 1 T exists

in region $y > 0$ is along $\hat{k}$ direction as shown. A particle of charge 1 C is projected from point $(-\sqrt{3}, -1)$ towards origin with speed 1 m/sec. If mass of particle is 1 kg, then co-ordinates of centre of circle in which particle moves are



(a) $(1, \sqrt{3})$ (b) $(1, -\sqrt{3})$

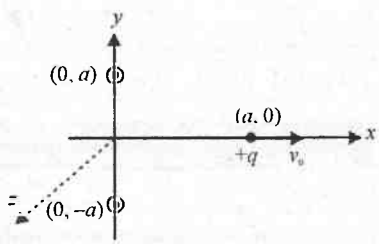
(c) $\left(\frac{1}{2}, -\frac{\sqrt{3}}{2}\right)$ (d) $\left(\frac{\sqrt{3}}{2}, -\frac{1}{2}\right)$

28. A uniform magnetic field exists in region which forms an equilateral triangle of side a. The magnetic field is perpendicular to the plane of the triangle. A charge q enters into this magnetic field perpendicularly with speed v along perpendicular bisector of one side and comes out along perpendicular bisector of other side. The magnetic induction in the triangle is

(a) $\frac{mv}{qa}$ (b) $\frac{2mv}{qa}$

(c) $\frac{mv}{2qa}$ (d) $\frac{mv}{4qa}$

29. Two long conducting wires fixed at point $(0, a)$ and $(0, -a)$ carrying equal currents in $+z$ direction. A positive charged particle is projected with velocity u_0 from the point $(a, 0)$ as shown in figure, the electric field at that point so that particle will not experience any force there, is (space is gravity free)



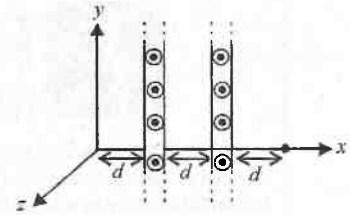
(a) $\frac{\mu_0 i v_0}{2\pi a}$ along $+z$ direction

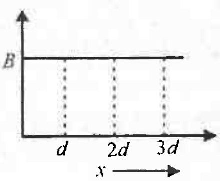
(b) $\frac{\mu_0 i v_0}{2\pi a}$ along $-z$ direction

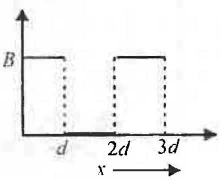
(c) $\frac{\mu_0 i v_0}{2\sqrt{2}\pi a}$ along $-z$ direction

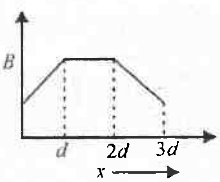
(d) $\frac{\mu_0 i v_0}{2\sqrt{2}\pi a}$ along $+z$ direction

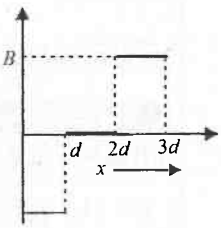
30. Two large conducting current planes perpendicular to x-axis are placed at $(d, 0)$ and $(2d, 0)$ as shown in figure. Current per unit width in both the planes is same and current is flowing in the outward direction. The variation of magnetic induction as function of x $(0 < x \leq 3d)$ is best represented by



(a)


(b)


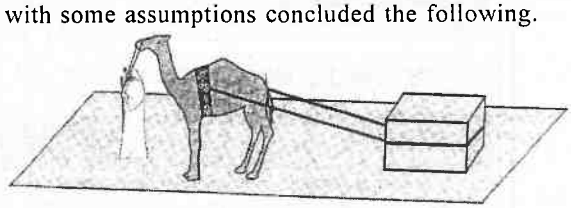
(c)


(d)


PASSAGE-1 : (Read the following passage and answer the questions numbered 31 to 35. They have only one correct option)

Ram and Ali are two fast friends since childhood. Ali neglected studies and now has no means to earn money other than a camel whereas Ram becomes an engineer. Now both are working in the same factory. Ali uses camel to transport the load within the factory.

Due to low salary and degradation in health of camel, Ali becomes worried and meet his friend Ram and discusses his problem. Ram collected some data and with some assumptions concluded the following.



(i) The load used in each trip is 1000 kg and has friction coefficient $\mu_k = 0.1$ and $\mu_s = 0.2$.

(ii) Mass of camel is 500 kg.

(iii) Load is accelerated for first 50 m with constant acceleration, then it is pulled at a constant speed of 5 m/s for 2 km and at last stopped with constant retardation in 50 m.

(iv) From biological data, the rate of consumption of energy of camel can be expressed as $P = 18 \times 10^3 V + 10^4$ J/s where P is the power and V is the velocity of the camel.

After calculations on different issues Ram suggested proper food, speed of camel etc. to his friend. For the welfare ofAli, Ram wrote a letter to the management to increase his salary.

(Assuming that the camel exerts a horizontal force on the load) :

31. Sign of work done by the camel on the load during parts of motion : accelerated motion, uniform motion and retarted motion respectively are

(a) +ve, +ve, +ve (b) +ve, +ve, –ve
(c) +ve, zero, –ve (d) +ve, zero, +ve

32. The ratio of magnitude of work done by camel on the load during accelerated motion to retarded motion is

(a) 3 : 5 (b) 2.2 : 1
(c) 1 : 1 (d) 5 : 3

33. Maximum power transmitted by the camel to load is

(a) 6250 J/s (b) 5000 J/s
(c) 10^5 J/s (d) 1250 J/s

34. The ratio of the energy consumed of the camel during uniform motion for the two cases when it moves with speed 5 m/s to the case when it moves with 10 m/s

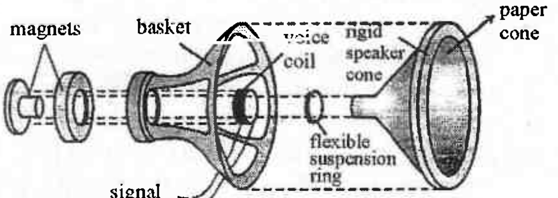
(a) 19/20 (b) 19/10
(c) 10/19 (d) 20/19.

35. The total energy consumed of the camel during the trip of 2100 m is

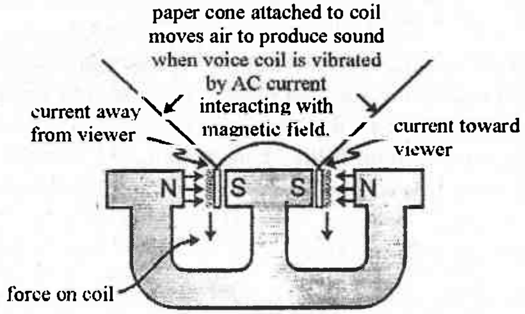
(a) 2.1×10^6 J (b) 4.22×10^7 J
(c) 2.22×10^4 J (d) 4.22×10^6 J

PASSAGE-2 : (Read the following passage and answer the questions numbered 36 to 40. They have only one correct option)

Components of loudspeaker : A loudspeaker consists of permanent magnets, basket, voice coil, flexible suspension ring and rigid speaker cone as shown in figure.



Loudspeaker principle : A light voice coil is mounted so that it can move freely inside the magnetic field of a strong permanent magnet. The paper cone is attached to the voice coil and attached with a flexible mounting to the outer ring of the speaker support. Because there is a definite equilibrium position for the speaker cone and there is elasticity of the mounting structure, there is inevitably a free cone resonant frequency like that of a mass on a spring. The frequency can be determined by adjusting the mass and stiffness of the cone and voice coil.

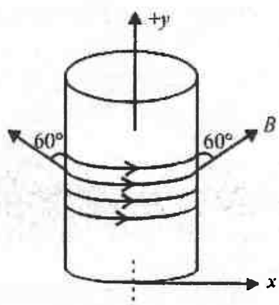


Working : The radio drives a rapidly changing current through the coil. The current follows the vibrations of speech and the electromagnetic force follows the current changes, pushing the paper cone. Finally the air in front of the loudspeaker is set into vibration following the cone's motion, and sound waves are transmitted to the listener.

36. The principle of loudspeaker is

(a) it converts mechanical energy into electrical energy
(b) permanent magnet exerts force on the coil
(c) the voice coil carrying current experiences torque due to which cone rotates and sound is produced.
(d) paper cone attached to coil moves air to produce sound when the voice coil is vibrated by an AC current interacting with magnetic field.

37. A voice coil in a loudspeaker has 40 turns of wire and loop-diameter 1 cm and the current in the coil is 1 A. Assume that the magnetic field at each of the wire of the coil has constant magnitude 0.2 T and is directed at an angle 60° from the normal to the plane of the coil as shown in figure. The magnitude and direction of magnetic force on the coil is



(a) $4\pi \times 10^{-2}$ N, $+y$ (b) $4\pi \times 10^{-2}$ N, $-y$
(c) $4\sqrt{3}\,\pi \times 10^{-2}$ N, $+y$ (d) $4\sqrt{3}\,\pi \times 10^{-2}$ N, $-y$

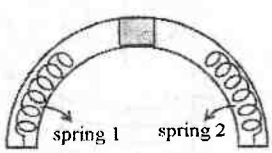
38. With reference to the figure of Q.37 when the current in the coil is given by $I = I_0 \cos(2000\pi t)$ where t is in seconds, the coil will experience magnetic force in the positive y-direction in the time intervals of : [Take the initial direction of current shown in figure to be positive]
(a) 0 to 5×10^{-4} sec (b) 2.5×10^{-4} to 5×10^{-4} sec
(c) 0 to 2.5×10^{-4} sec
(d) 2.5×10^{-4} to 7.5×10^{-4} sec

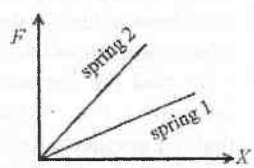
39. If the diameter of the cylindrical magnet, number of turns of the coil and cross section area of the wire of the coil are all doubled, then the magnetic force on the coil assuming the same potential difference, is (assume that value of magnetic field also gets doubled.)
(a) same (b) doubled
(c) becomes 8 times (d) becomes four times

40. If the voice coil is wound loosely and there is an approachable gap between two consecutive turns; when the current is passed through coil
(a) it tries to contract.
(b) it tries to expand.
(c) current has no effect on coil.
(d) coil will get contracted without current due to fixed magnets in loudspeaker.

One or more than one options may be correct (For Q.No. 41 to 55):

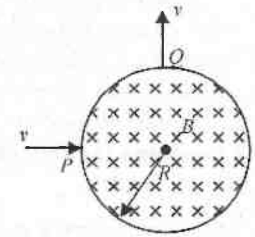
41. In the figure, a block rests on the top of a smooth fixed hemispherical tube of radius R in which it can just fit. Two springs are connected to the base as shown. The block is given a small jerk so that it can slide on the hemisphere. The F-X (F is magnitude of force and X is compression) graph for the springs is given below. Which of the following may be possible?





(a) The block will compress both springs by same amount.
(b) The block will compress the springs during its to and fro motion about its original position by different amounts.
(c) The block will perform to and fro motion along the hemispherical surface about the original position.
(d) The block can never come to the original position.

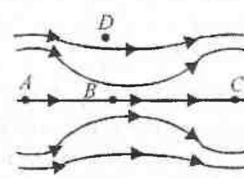
42. A particle of charge q and mass m enters normally (at point P) in a region of magnetic field with speed v. It comes out normally from Q after time T as shown in figure. The magnetic field B is present only in the region of radius R and is uniform. Initial and final velocities are along radial direction and they are perpendicular to each other. For this to happen, which of the following expression(s) is/are correct?



(a) $B = \dfrac{mv}{qR}$ (b) $T = \dfrac{\pi R}{2v}$
(c) $T = \dfrac{\pi m}{2qB}$ (d) none of these.

43. There are two massless springs A and B of spring constant k_A and k_B respectively and $k_A > k_B$. If W_A and W_B be denoted as work done on A and work done on B respectively, then
(a) if they are compressed to same distance, $W_A > W_B$
(b) if they are compressed by same force (upto equilibrium state) $W_A < W_B$
(c) if they are compressed by same distance, $W_A = W_B$
(d) if they are compressed by same force (upto equilibrium state) $W_A > W_B$

44. A space has magnetic field in which the lines of induction are as shown in the figure.



(a) The magnetic induction at B is greater than the magnetic induction at C.
(b) An electron placed at B experiences a larger force at B than that at C.
(c) An electron shot with a velocity towards D, perpendicular to the lines of induction at B in the plane of the figure will emerge from its opposite corner.
(d) An electron shot with a velocity along the line ABC will continue to be moving in the same direction.

45. Which of the following statements is/are incorrect?

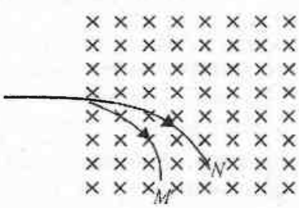
(a) No net force acts on a rectangular coil carrying a steady current when suspended freely in a uniform magnetic field.
(b) A charged particle enters a region of uniform magnetic field at an angle of 85° to the magnetic lines of forces. The path of the particle is a circle.
(c) When a body is free to slide down a rough inclined plane at a constant velocity, the direction of the total force exerted by the plane on the body is vertical.
(d) When a body is at instantaneous rest, it must be in equilibrium.

46. Column **X** gives four physical quantities. Select the appropriate units for these from the options given in column **Y**. For some of the physical quantities, there may be more than one correct choice.

X	**Y**
(i) Permittivity	A. $(\text{joule})^1\ (\text{amp})^{-2}$
	B. $(\text{farad})^1\ (\text{amp})^2\ (\text{ohm})^2$
(ii) Magnetic permeability	C. $(\text{joule})^1\ (\text{metre})^{-2}\ (\text{amp})^{-1}$
	D. $(\text{coul})^2\ (\text{metre})^{-2}\ (\text{newton})^{-1}$
(iii) Magnetic induction	E. $(\text{coul})^1\ (\text{newton})^1\ (\text{sec})^1\ (\text{metre})^{-1}$
	F. $(\text{henry})^1\ (\text{volt})^2\ (\text{ohm})^{-2}$
(iv) Energy	G. $(\text{coul})^1\ (\text{newton})^1 (\text{joule})^{-1} (\text{metre})^{-1}$

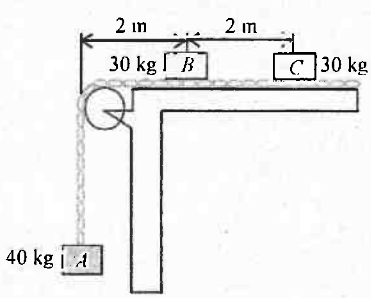
(a) (i) - D (b) (ii) - A
(c) (iii) - C, E (d) (iv) - B, F

47. Two charged particles M and N enter a space of uniform magnetic field, with velocities perpendicular to the magnetic field. The paths are as shown in the figure. The possible reasons for different paths may be



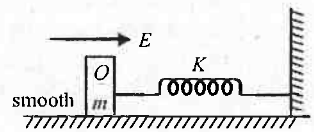
(a) the charge of M is greater than that of N
(b) the momentum of M is greater than that of N
(c) specific charge of M is greater than that of N
(d) the speed of M is less than that of N.

48. Two 30 kg blocks rest on a massless belt which passes over a fixed pulley and is attached to a 40 kg block. If coefficient of friction between the belt and the table as well as between the belt and the blocks B and C is μ and the system is released from rest from the position shown, the speed with which the block B falls off the belt is



(a) $2\sqrt{2}$ m/s if $\mu = 0.2$ (b) $\sqrt{2}$ m/s if $\mu = 0.2$
(c) 2 m/s if $\mu = 0.5$ (d) 2.5 m/s if $\mu = 0.5$

49. In the figure shown, initially the spring of negligible mass is in underformed state and the block has zero velocity E is a uniform electric field. Then



(a) the maximum speed of the block will be $\frac{QE}{\sqrt{mK}}$
(b) the maximum speed of the block will be $\frac{2QE}{\sqrt{mK}}$
(c) the maximum compression of the spring will be $\frac{QE}{K}$
(d) the maximum compression of the spring will be $\frac{2QE}{K}$.

50. Which of the following quantities is/are frame dependent?
(a) magnetic field due to current carrying wire
(b) work done by a force on a particle
(c) potential energy (d) kinetic energy

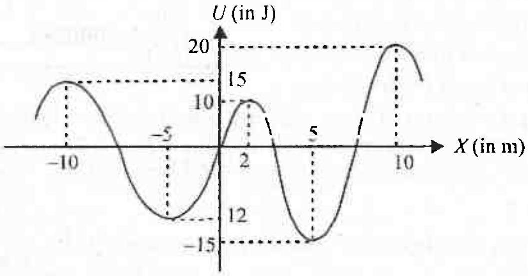
51. A block A (5 kg) rests over another block B (3 kg) placed over a smooth horizontal surface. There is friction between A and B. A horizontal force F_1 gradually increasing from zero to a maximum is applied to A so that the blocks move together without relative motion. Instead of this another horizontal force F_2, gradually increasing from zero to a maximum is applied to B so that the blocks move together without relative motion. Then

(a) F_1 (max) = F_2 (max)
(b) F_1 (max) > F_2 (max)
(c) F_1 (max) < F_2 (max)
(d) F_1 (max): F_2 (max) = 5: 3

52. Which of the following is/are conservative force(s)?
(a) $\vec{F} = 2r^3\hat{r}$ (b) $\vec{F} = -\frac{5}{r}\hat{r}$

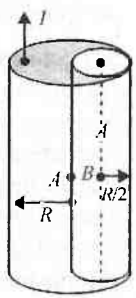
(c) $\vec{F} = \dfrac{3(x\hat{i} + y\hat{j})}{(x^2+y^2)^{3/2}}$ (d) $\vec{F} = \dfrac{3(y\hat{i} + x\hat{j})}{(x^2+y^2)^{3/2}}$

53. In the figure the variation of potential energy of a particle of mass $m = 2$ kg is represented w.r.t. its x-coordinate. The particle moves under the effect of this conservative force along the x-axis. Which of the following statements is/are correct about the particle?



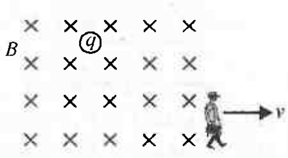
(a) If it is released at the origin it will move in negative x-axis.
(b) If it is released at $x = 2 + \Delta$ where $\Delta \to 0$ then its maximum speed will be 5 m/s and it will perform oscillatory motion.
(c) If initially $x = -10$ and $\vec{u} = \sqrt{6}\hat{i}$ then it will cross $x = 10$.
(d) $x = -5$ and $x = +5$ are unstable equilibrium positions of the particle.

54. From a cylinder of radius R, a cylinder of radius $R/2$ is removed, as shown. Current flowing in the remaining cylinder is I. Magnetic field strength is



(a) zero at point A
(b) zero at point B
(c) $\dfrac{\mu_0 I}{3\pi R}$ at point A
(d) $\dfrac{\mu_0 I}{3\pi R}$ at point B

55. A charged particle is kept at rest on a smooth horizontal surface in uniform mangetic field B which is directed downwards as shown in the figure. An observer is moving with constant velocity v towards right. Then with respect to the observer which of the following statements is/are correct ?



(a) path of the charged particle will be straight line
(b) path of charged particle will be circular
(c) magnetic force on the charged particle is zero
(d) magnitude of magnetic force on charged particle is qVB.

ANSWERS

1. (d)	2. (a)	3. (a)	4. (a)	5. (d)
6. (a)	7. (b)	8. (b)	9. (b)	10. (c)
11. (a)	12. (b)	13. (a)	14. (b)	15. (a)
16. (b)	17. (b)	18. (b)	19. (a)	20. (c)
21. (a)	22. (d)	23. (b)	24. (a)	25. (b)
26. (d)	27. (c)	28. (b)	29. (b)	30. (d)
31. (a)	32. (d)	33. (a)	34. (d)	35. (b)
36. (d)	37. (d)	38. (d)	39. (d)	40. (a)
41. (b, c)	42. (a, b, c)		43. (a, b)	
44. (a, d)	45. (b, d)	46. (a, d)	47. (a, c, d)	
48. (a, c)	49. (a, d)	50. (b, c, d)		
51. (b, d)	52. (a, b, c)		53. (a, b, c)	
54. (c, d)	55. (a, d)			

Note : For detailed solutions please log on to our website www.resonance.ac.in

EXAM ALERT

ALL INDIA INSTITUTE OF MEDICAL SCIENCES (AIIMS - 2006)

Applications are invited in prescribed form for admission to **MBBS Course** commencing on **1st August, 2006**. Entrance Examination will be held on **01.06.2006** (Thursday).

Eligibility Criteria : Candidates who have passed 12th class examination under 10 + 2 system or an equivalent examination with Physics, Chemistry, Biology and English, securing a minimum 60% marks (50% in case of Scheduled Caste/Scheduled Tribe candidates) in aggregate in Physics, Chemistry, Biology and English or whose results of Class - XII are likely to be declared by mid July, 2006 are eligible to apply.

Schedule of sale of prospectus-cum-application forms:

1. Against cash payment by selected branches of S.B.I. (except AIIMS Campus, Ansari Nagar, New Delhi) - **03.01.2006** to **17.02.2006**
2. Against cash payment from S.B.I., AIIMS Campus, Ansari Nagar, New Delhi - **03.01.2006** to **24.02.2006**
3. By post against Bank Draft from the Office of Asstt. Controller of Examinations, AIIMS - **03.01.2006** to **17.02.2006**
4. Last date for receipt of completed applications at Examination Section, A.I.I.M.S - **24.02.2006** by 5:00 p.m.

For more details see exam alert on pcmbtoday.com or mtg.in

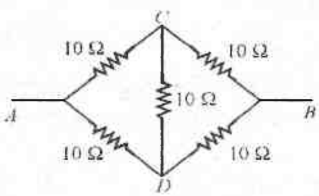
UP CPMT - 2005*

1. The time constant is given by
(a) L/R (b) R/L
(c) LR (d) $1/LR$.

2. Which colour shows ınaximim deviation when passed through a prism?
(a) white (b) red
(c) violet (d) green.

3. A person standing in front of a mirror finds his image larger than himself. This implies that the mirror is
(a) concave (b) convex
(c) plane (d) none of these.

4. The equivalent resistance between A and B in the given circuit is



(a) 10 Ω
(b) 20 Ω
(c) 30 Ω
(d) 40 Ω.

5. A galvanometer can be converted into voltmeter by a
(a) low resistance in series
(b) high resistance in parallel
(c) low resistance in series
(d) high resistance in series.

6. The dimension of Planck's constant is equal to
(a) work (b) force
(c) angular momentum (d) linear momentum.

7. A car is moving along a straight horizontal road with a speed of 72 km/hr. If the coefficient of static friction between road and tyres is 0.5, the shortest distance in which the car can be stopped is
(a) 40 m (b) 80 m
(c) 90 m (d) 180 m.

8. A ball of mass m elastically collides with a wall with velocity v, then change in momentum is equal to
(a) $2m$ (b) $2mv$
(c) $-2mv$ (d) $2v$.

9. Which of the following statement is correct for PN-junctions?
(a) in depletion layer immovable ions exist
(b) the current in the reverse biased condition is generally very small
(c) PN-junction diode is reverse biased then barrier potential increases
(d) all of these.

10. If a spring is divided into n equal parts then k of one spring becomes
(a) $\frac{n}{n+1}k$ (b) $\left(\frac{n}{n+1}\right)k$
(c) nk (d) $\frac{k}{n+1}$

11. Intensity of sound wave depends on
(a) frequency as well as amplitude
(b) frequency only (c) amplitude only
(d) number of overtone.

12. If a charge q_1 and q_2 in e.s.u. kept at a distance r cm apart the potential energy of the system is
(a) $\frac{Kq_1q_2}{r}$ (b) $\frac{Kq_1q_2}{r^2}$
(c) $\frac{Kq_1q_2}{3r}$ (d) $\frac{Kq_1q_2}{3r^2}$

13. If half-life of a substance is 4 days then amount of substance left after 2 days is
(a) $\frac{1}{\sqrt{2}}$ (b) $\frac{\sqrt{2}-1}{\sqrt{2}}$
(c) $\sqrt{2}$ (d) $\frac{\sqrt{2}+1}{\sqrt{2}}$

14. A 20 kg body requires 75 N to start the motion. If 60 N force is required to continue the motion then the coefficient of kinetic friction is
(a) 0.42 (b) 0.53
(c) 0.31 (d) 0.25

15. For a capacitor to hold maximum charge it must have

* *Based on memory*

(a) large radius (b) hollow sphere
(c) solid sphere (d) small radius.

16. When a gas expands adiabatically
(a) no energy is required for expansion
(b) energy is required and it comes from the wall of the container of the gas
(c) internal energy of the gas is used in doing work
(d) law of conservation of energy does not hold.

17. Earth radius can be measured by
(a) orbiting the satellite around the earth at two different positions
(b) by the measurement of centre of gravity
(c) by the value of g
(d) by Cavendish value G, centre of gravity, the value of g.

18. A geostationary satellite has an orbital period of
(a) 2 hr (b) 12 hr
(c) 6 hr (d) 24 hr.

19. The radius of the Bohr orbit depends on
(a) $1/n$ (b) n
(c) $1/n^2$ (d) n^2.

20. If the distance between the plates of a parallel plate condenser is halved and the dielectric is doubled, then its capacity will
(a) remain the same (b) increases by 4 times
(c) increases by 2 times
(d) increase by 16 times.

21. Resonance is a special case of
(a) damped vibration (b) natural vibration
(c) un-damped vibration (d) forced vibration.

22. First law of thermodynamics states that
(a) system can do work
(b) system has pressure
(c) system has temperature
(d) heat is a form of energy.

23. A thermoelectric refrigerator works on
(a) Seebeck effect (b) Peltier effect
(c) Joule effect (d) photoelectric effect.

24. The bread gives a boy 5000 cals. How much height he can climb by using this energy of his efficiency is 28%. (mass of the body = 40 kg).
(a) 5 m (b) 15 m
(c) 10 m (d) 22 × 5 m.

25. The energy produced in the sun is due to
(a) fission reaction (b) fusion reaction
(c) motion of electrons and ions
(d) chemical reaction.

26. If the luminous-efficiency of a lamp is 2 lumen/watt and its luminous intensity is 42 candela, then the power of the lamp is
(a) 62 watt (b) 138 watt
(c) 76 watt (d) 264 watt.

27. An ideal gas at 27°C is compressed adiabatically from 27 unit volume to 8 unit volume. If $\gamma = 5/3$, then the rise of temperature is
(a) 145°C (b) 370°C
(c) 225°C (d) 402°C.

28. The period of revolution of a certain planet in an orbit of radius R is T. Its period of revolution in an orbit of radius $4R$ will be
(a) T (b) $\sqrt{4}T$
(c) $\sqrt{2}T$ (d) $8T$.

29. If a cycle wheel of radius 4 m completes one revolution in two seconds then acceleration of the cycle is
(a) 4 m/s^2 (b) $2\pi^2$ m/s^2
(c) π^2 m/s^2 (d) $4\pi^2$ m/s^2.

30. A force of 50 dynes is acted on a body of mass 5 g which is at rest for an interval of 3 sec, then impulse is
(a) 0.16×10^{-3} N-s (b) 1.5×10^{-3} N-s
(c) 0.98×10^{-3} N-s (d) 2.5×10^{-3} N-s

31. When a source is going away from a stationary observer with the velocity equal to that of sound in air, then the frequency heard by observer will be
(a) same (b) double
(c) half (d) one third.

32. For the stability of any nucleus
(a) binding energy per nucleon will be more
(b) binding energy per nucleon will be less
(c) number of electrons will be more
(d) none of these.

33. If the critical angle for total internal reflection from a medium to vacuum is 30°, the velocity of light in the medium is
(a) 3×10^8 m/s (b) $\sqrt{3} \times 10^8$ m/s
(c) 6×10^8 m/s (d) 1.5×10^8 m/s.

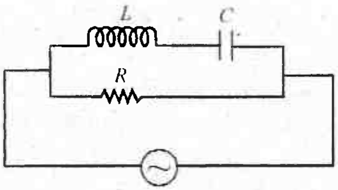
34. A light of wavelength 4000 Å is allowed to fall on a metal surface having work function 2 eV. The maximum velocity of the emitted electron is

(a) 1.35×10^5 m/s (b) 6.2×10^5 m/s
(c) 2.7×10^5 m/s (d) 8.1×10^5 m/s.

35. If a half wave rectifier is used to convert 50 Hz a.c. into d.c then the number of pulses present in rectified voltage is

(a) 25 (b) 50
(c) 100 (d) 75.

36. In the circuit shown in figure at resonance



(a) the power factor is zero
(b) the current through the a.c. source is minimum
(c) the current through the a.c. source is maximum
(d) currents through L and R are equal.

37. When light travels from air to water which parameter does not change?

(a) wavelength (b) frequency
(c) velocity (d) all of these.

38. The difference between soft and hard X-rays is of

(a) velocity (b) intensity
(c) frequency (d) polarization.

39. If v_m, v_x and v_g are the speeds of microwave, X-rays and gamma rays respectively in vacuum then

(a) $v_g > v_x > v_m$ (b) $v_g < v_x < v_m$
(c) $v_g > v_x < v_m$ (d) $v_g = v_m = v_x$

40. A material is placed in a magnetic field and it is thrown out of it. Then the material is

(a) paramagnetic (b) diamagnetic
(c) ferromagnetic (d) non-magnetic.

41. Two long parallel wires carry equal currents I in the same direction. The length of each wire is l and the distance between them is a. Force acting on each wire is

(a) $\dfrac{\mu_0 I l^2}{2\pi a}$ (b) $\dfrac{\mu_0 I l}{2\pi a^2}$
(c) $\dfrac{\mu_0 l^2 I^2}{4\pi a^2}$ (d) $\dfrac{\mu_0 I l^2}{4\pi a^2}$

42. At 10 Ω electric heater supplies on a 110 V line. Calculate the rate at which it develops heat in watts.

(a) 670 (b) 810
(c) 1210 (d) 1310.

43. A wave is represented by $x = 0.4\cos\left(8t - \dfrac{y}{2}\right)$ where x and y are in metres and t in seconds. The speed of the wave is

(a) 0.5 m/s (b) 8 m/s
(c) 16 m/s (d) 6 m/s.

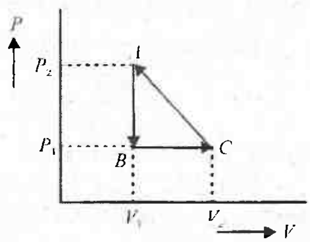
44. If a body is released into a tunnel dug along the diameter of the earth of radius R_0, it executes the simple harmonic motion with time period

(a) $T = 2\pi\sqrt{\dfrac{R_0}{g}}$ (b) $T = 2\pi\sqrt{\dfrac{2R_0}{g}}$
(c) $T = 2\pi\sqrt{\dfrac{R_0}{2g}}$ (d) $T = 2$.

45. 540 g of ice at 0°C is mixed with 540 g of water at 80°C. The final temperature of the mixture in °C will be

(a) 40°C (b) 79.9°C
(c) 0°C (d) 80°C.

46. Work done by the system in closed path $ABCA$



(a) zero
(b) $\dfrac{(P_2 - P_1)(V_2 - V_1)}{2}$
(c) $(V_1 - V_2)(P_1 - P_2)$
(d) $\dfrac{(P_2 + P_1)(V_2 - V_1)}{2}$

47. At which the following temperatures the value of surface tension of water is minimum?

(a) 4°C (b) 25°C
(c) 50°C (d) 75°C.

48. On increasing the temperature of a substance its colour become

(a) red (b) yellow
(c) green (d) white.

49. A nucleus ${}_nX^m$ emits one α and one β particle. The resulting nucleus is

(a) ${}_nX^{m-4}$ (b) ${}_{n-2}X^{m-4}$
(c) ${}_{n-4}Z^{m-4}$ (d) ${}_{n-1}Z^{m-4}$.

50. The relation between amplification factor (μ), plate resistance (r_p) and mutual conductance (g_m) of a triode valve is given by

(a) $\mu = r_p \times g_m$ (b) $r_p = \mu \times g_m$
(c) $g_m = \mu \times r_p$ (d) none of these.

SOLUTIONS

1. (a) : As L/R is time constant of RL circuit, so its dimensions are $[M^0L^0T]$.

2. (c) : Deviation $\delta = (\mu - 1)A$
For violet colour μ is maximum. Therefore δ is maximum for violet colour.

3. (a) : The size of the image is more than the size of object, so the mirror is concave.

4. (a) : It is balanced Wheatstone bridge because

$$\frac{P}{Q} = \frac{10}{10} = \frac{1}{1} \text{ and } \frac{R}{S} = \frac{10}{10} = \frac{1}{1}.$$

Therefore resistance between C and D is ineffective so total resistance between A and B

$$= \frac{(10+10)(10+10)}{(10+10)+(10+10)} = \frac{20\times 20}{20+20} = 10\ \Omega.$$

5. (d) : To convert galvanometer into a voltmeter we connect a high resistance in series of galvanometer.

6. (c) : Dimensions of Planck's constant (h)

$$[h] = \frac{[E]}{[\upsilon]} = \frac{[ML^2T^2]}{[T^{-1}]} = [ML^2T^{-1}]$$

Angular momentum, $[L] = [I]\ [\omega]$
$= [ML^2]\ [T^{-1}] = [ML^2T^{-1}]$.
Hence dimension of Planck's constant is equal to angular momentum.

7. (a) : Opposing force on a car is the force of friction, $F = \mu g$.

$\therefore$ Reatardation, $a = \dfrac{F}{m} = \dfrac{\mu mg}{m} = \mu g$

$= 0.5 \times 10 = 5\ m/s^2$.

$u = 72$ km/hr $= \dfrac{72\times 1000}{3600} = 20$ m/s.

$v = 0$, $a = -5\ m/s^2$.
By third equation of motion, $v^2 = u^2 + 2as$
$0 = (20)^2 + 2(-5)(s)$
or, $s = (20)2/10 = 40$ m.
Hence, the shortest distance in which the car can be stopped is 40 m.

8. (b) : Since the collision is elastic, so the ball returns with velocity v.
$\therefore$ Change in momentum $= mv - (-mv) = 2mv$.

9. (d)

10. (c) : When a spring constant k is cut into n equal parts, then spring constant of each part is nk.

11. (a) : Intensity of sound $(I) \propto$ (amplitude)^2.
Also, $I \propto$ (frequency)^2
Hence, intensity of sound depends both amplitide as well as frequency.

12. (a) : Potential energy of the system

$$= \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r} = K\frac{q_1q_2}{r}, \text{ where } K = 1/4\pi\varepsilon_0.$$

13. (a) : $N = N_0(1/2)^n$
where n = number of half lives $= t/T$

$$\therefore \frac{N}{N_0} = \left(\frac{1}{2}\right)^{2/4} = \left(\frac{1}{2}\right)^{1/2} \text{ or, } \frac{N}{N_0} = \frac{1}{\sqrt{2}}$$

Hence the amount of susbtance left after two days is $1/\sqrt{2}$.

14. (c) : Force of friction = force required to keep the body moving constant speed, *i.e.*, $F = 60$ N.

$$\therefore \mu = \frac{F}{R} = \frac{60}{20\times 9.8} = 0.31$$

15. (a) : Capacity $(C) = 4\pi\varepsilon_0 r$
Capacity of a spherical capacitor depends on the radius. Hence, capacitor of larger sphere hold maximum charge.

16. (c) : According to 1st law of thermodynamics

$$dQ = dU + dW$$

For adiabatic expansion, $dQ = 0$
$\therefore$ $dU = dW$.

17. (c) : Earth radius can be measured by the value of g.

$\because$ $g = \dfrac{GM_e}{R_e^2}$, where M_e = mass of earth

R_e = radius of earth, G = gravitational constant.

18. (d) : A geostationary satellite resolves around the earth from west to east with the same angular velocity as the earth. Its period of revolution is one day *i.e.* 24 hours.

19. (d) : Radius of n^{th} Bohr orbit is $r_n \propto n^2$.

20. (b) : Capacity of a condenser, $C = \dfrac{\varepsilon_0 KA}{d}$

$\therefore$ $C \propto (K/d)$

Therefore, $\frac{C_1}{C_2} = \left(\frac{K_1}{d_1}\right)\left(\frac{d_1/2}{2K_1}\right) = \frac{1}{4}$ or, $\frac{C_2}{C_1} = 4$

Hence capacity will increase by 4 times.

21. (d) : Resonance is a special case of forced vibration.

22. (d) : According to first law of thermodynamics heat is a form of energy.

23. (b) : Thermoelectric refrigerator is based on the Peltier effect.

24. (b) : Energy received by a boy from bread

= 5000 cals = 5000 × 4.2 = 21 × 10^3 J.

According to law of conservation of energy

$$mgh = \frac{28}{100} \times 21 \times 10^3$$

$$\therefore \quad h = \frac{28 \times 21 \times 10^3}{100 \times 9.8 \times 40} = 15 \text{ m.}$$

25. (b) : In the sun, energy is produced due to fusion reaction.

26. (d) : Luminous flux (ϕ) = $4\pi I$

where I = luminous intensity

$\therefore$ $\phi = 4\pi \times 52 = 527.5$ lumen

Since luminous efficiency = $\frac{\text{luminous flux}}{\text{power}}$

$\therefore$ Power of the lamp = $\frac{527.5}{2} = 263.7 = 264$ watt.

27. (d) : For adiabatic compression $TV^{\gamma-1}$ = constant.

Given : T_1 = 27°C = 300 K

V_1 = 27 unit; V_2 = 8 unit

$\gamma = 5/3$.

$$\therefore \quad T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1} \quad \text{or,} \quad T_2 = T_1\left(\frac{V_1}{V_2}\right)^{\gamma-1}$$

$$\Rightarrow \quad T_2 = 300\left(\frac{27}{8}\right)^{\frac{5}{3}-1} = 300\left(\frac{9}{4}\right) = 675 \text{ K}$$

or, T_2 = 675 − 273 = 402°C.

28. (d) : Time period of revolution of a planet in an orbit is T.

According to Kepler's third law,

$T^2 \propto R^3$

$$\text{or,} \quad \left(\frac{T_1}{T_2}\right)^2 = \left(\frac{R_1}{R_2}\right)^3 \quad \text{or,} \quad T_2 = T_1\left(\frac{R_2}{R_1}\right)^{3/2}$$

$$\text{or,} \quad T_2 = T\left(\frac{4R}{R}\right)^{3/2} \quad \text{or,} \quad T_2 = 8T.$$

29. (d) : Angular velocity, $\omega = 2\pi/T$

$\therefore$ $\omega = \frac{2\pi}{T} = \pi$ rad/sec.

$\therefore$ Centripetal acceleration = $\omega^2 r = \pi^2 r = 4\pi^2$ m/s².

30. (b) : Force, F = 50 dynes = 50 × 10^{-5} N

= 5 × 10^{-4} N

Impulse = force × time

$\therefore$ Impulse = 5 × 10^{-4} × 3 = 15 × 10^{-4}

= 1.5 × 10^{-3} N-s.

31. (c) : The frequency heard by the observer

$$n' = \frac{nv}{v+v} = \frac{1}{2}n.$$

32. (a) : For the stability of the nucleus it should have high binding energy per nucleon.

33. (d) : $\sin C = \frac{1}{\mu} = \frac{v}{c}$

$v = c\sin C = 3 \times 10^8 \times \sin 30° = 1.5 \times 10^8$ m/s.

34. (b) : $\frac{1}{2}mv^2 = \frac{hc}{\lambda} - W_0(\text{eV})$

$$= \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{4000 \times 10^{-10} \times 1.6 \times 10^{-19}} - 2 = 3.1 - 2$$

= 1.1 eV = 1.76 × 10^{-19} J.

$$\therefore \quad v^2 = \frac{2 \times 1.76 \times 10^{-19}}{9.1 \times 10^{-31}} = 0.387 \times 10^{12}$$

or, $v = 6.2 \times 10^5$ m/s.

35. (b) : 50 Hz a.c. has 100 pulses/sec. In half wave rectifier negative pulses are missing. Therefore, rectified voltage has 50 pulses/sec.

36. (c) : In the circuit shown L and C are in series. Therefore, it is a series resonance circuit. Hence current through a.c. source is maximum.

37. (b) : In going from air to water frequency remains the same.

38. (c) : The X-rays having large wavelength and low frequency are soft X-rays whereas X-rays having small wavelength and high frequency are hard X-rays, so difference is of frequency.

39. (d) : Microwaves, gamma rays and X-rays are electromagnetic waves. In vacuum, these waves travel with the same speed.

i.e. velocity of light (3×10^8 m/s).

$\therefore \quad v_g = v_m = v_x$.

40. (b) : Diamagnetic material is repelled by the magnetic field therefore when a diamagnetic material is placed in a magnetic field it is thrown out of it.

41. (a) : Force acting on each wire,

$$F = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{a}l = \frac{\mu_0}{4\pi}\frac{2I^2l}{a} = \frac{\mu_0}{2\pi}\frac{I^2l}{a}$$

42. (c) : Heat developed per second $= \dfrac{V^2}{R} = \dfrac{(110)^2}{10}$
$= 1210$ watt

43. (c) : Given equation : $x = 0.4\cos\left(8t - \dfrac{y}{2}\right)$

Compare the given equation with standard equation

$$x = a\cos\left(2\pi\upsilon t - \frac{2\pi y}{\lambda}\right)$$

we get, $2\pi\upsilon = 8$ or, $\upsilon = \dfrac{8}{2\pi}$

$$\frac{2\pi}{\lambda} = \frac{1}{2} \quad \text{or,} \quad \lambda = 4\pi$$

Speed of the wave, $v = \upsilon\lambda$

$$\therefore \quad v = \frac{8}{2\pi} \times 4\pi = 16 \text{ m/s.}$$

44. (a) : $T = 2\pi\sqrt{\dfrac{R_0}{g}}$.

45. (c) : Heat required to melt 540 g of ice at 0°C
$= 540 \times 80 = 43200$ cals.

Heat lost by water in cooling from 80°C to 0°C
$= 540 \times 80 = 43200$ cals

Since both are equal, therefore, final temperature of mixture will become 0°C.

46. (b) : Work done by the system = area of ΔABC

$$= \frac{1}{2}AB \times BC = \frac{(P_2 - P_1)(V_2 - V_1)}{2}.$$

47. (d) : Surface tension of water decreases with increase in temperature, therefore at 75°C surface tension of water is minimum.

48. (a) : At 900°C, the colour of hot body is red.
At 1200°C, the colour of hot body is yellow.
At 1300°C, the colour of hot body is green.
At 1600°C, the colour of hot body is white.
Final colour = white.

49. (d) : An alpha particle has mass of 4 units and charge of 2 units. A β particle has negligible mass and carries unit negative charge with the emission of one α and one β particle, decrease in mass number 4 and decrease in charge number = 2 – 1 = 1.

$\therefore$ The resulting nucleus is ${}_{n-1}Z^{m-4}$.

50. (a) : $g_m = \dfrac{\Delta I_p}{\Delta V_g}$, $\mu = \dfrac{\Delta V_p}{\Delta V_g}$, $r_p = \dfrac{\Delta V_p}{\Delta I_p}$

$$\therefore \quad \mu = \frac{\Delta V_p}{\Delta V_g} = \frac{\Delta V_p}{\Delta I_p} \times \frac{\Delta I_p}{\Delta V_g} \quad \text{or,} \quad \mu = r_p \times g_m.$$

Practice Paper *for*

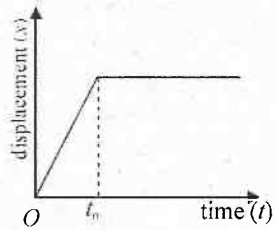
Exam on 22^{nd} and 23^{rd} April 2006

West Bengal JEE 2006

1. When two bodies move uniformly towards each other the distance between them decreases by 8 m/s. If both bodies move in the same direction with different speeds the distance between them increases by 2 m/s. The speeds of the two bodies will be

(a) 4 m/s and 3 m/s (b) 4 m/s and 2 m/s
(c) 5 m/s and 3 m/s (d) 7 m/s and 3 m/s.

2. Figure shows the displacement (x)-time (t) graph of a particle moving on the X-axis. Then



(a) the particle is at rest
(b) the particle is continuously going along X-direction
(c) the velocity of the particle increases upto time t_0 and then becomes constant
(d) the particle moves at a constant velocity up to a time t_0 and then stops.

3. The resultant of two vectors $(A + B)$ and $(A - B)$ is a force $\sqrt{3A^2 + B^2}$. The angle between two given forces is

(a) $\pi/4$ (b) $\pi/3$ (c) $\pi/2$ (d) π.

4. A particle of mass m moving with a velocity v make head on elastic collision with another particle of same mass and initially at rest. The velocity of first particle after collision is

(a) v (b) $-v$ (c) tv (d) 0.

5. A player caught a cricket ball of mass 150 grams, which was moving with a velocity of 20 m/s. If the catching process is completed in 0.1 second, the blow exerted by the ball on the hands of the player is

(a) 100 N (b) 30 N (c) 20 N (d) 15 N.

6. A body of mass 2 kg rests on a rough inclined plane making an angle 30° with the horizontal. The coefficient of static friction between the block and the plane is 0.7. The frictional force on the block is

(a) 9.8 N (b) $0.7 \times 9.8 \times \sqrt{3}$ N
(c) $9.8 \times \sqrt{3}$ N (d) 0.7×9.8 N.

7. A body of weight W is kept on a rough inclined plane having an angle of inclination with horizontal, θ and friction coefficient μ. Force required to pull the body downwards is

(a) $W(\mu\cos\theta + \sin\theta)$ (b) $W(\mu\cos\theta - \sin\theta)$
(c) $W(\sin\theta - \mu\cos\theta)$ (d) $W(\mu\cos\theta + 2\sin\theta)$.

8. The position of centre of mass of a system of particles does not depend upon

(a) masses of particles (b) forces on particles
(c) position of the particles
(d) relative distance between the particles.

9. A body is moving along a circular path with constant speed. If the direction of rotation is reversed and the speed is doubled, then

(a) direction of centripetal acceleration remains unchanged
(b) direction of centripetal acceleration is reversed
(c) magnitude of centripetal acceleration is doubled
(d) magnitude of centripetal acceleration is halved.

10. A curved road of diameter 1.8 km is banked so that no friction is required at a speed of 30 m/s. What is the banking angle?

(a) 6° (b) 16° (c) 26° (d) 0.6°.

11. Rotational analogue of force in linear motion is

(a) weight (b) angular momentum
(c) moment of inertia (d) torque.

12. The mass of an electron is 9×10^{-31} kg. It revolves around the nucleus of an atom in a circular orbit of 4.0 Å with a speed of 6×10^6 m/s. The angular momentum of electron is

(a) 2.16×10^{-33} kgm^2/s (b) 2×10^{-35} kgm^2/s
(c) 3×10^{-33} kgm^2/s (d) 3×10^{-35} kgm^2/s.

13. A body is under the action of two equal and opposite forces, each of 3 N. The body is displaced by 2 m. The work done is

(a) + 6 J (b) – 6 J
(c) 0 (d) none of these.

14. A 12 HP motor has to be operated 8 hours/day. How much will it cost at the rate of 50 paise/kWh in 1 day?

(a) Rs. 350/- (b) Rs. 358/-
(c) Rs. 375/- (d) Rs. 397/-

15. A rope ladder with a length l carrying a man with a mass m at its end is attached to the basket of a balloon with a mass M. The entire system is in equilibrium in air. As the man climbs up the ladder into the balloon, the balloon descends by a height h. Then the potential energy of the man

(a) increases by $mg(2l - h)$
(b) increases by mgh (c) increases by mgl
(d) increases by $mg(l - h)$.

16. If earth suddenly shrinks by one third of its present radius, the acceleration due to gravity will be

(a) $\frac{2}{3}g$ (b) $\frac{3}{2}g$ (c) $\frac{4}{9}g$ (d) $\frac{9}{4}g$

17. Two spheres of equal radius r are touching each other. The force of attraction between them is proportional to

(a) r^6 (b) r^4 (c) r^2 (d) r^{-2}.

18. Two pieces of wire A and B of the same material have their lengths in the ratio 1 : 2 and their diameters are in the ratio 2 : 1. If they are stretched by the same force, their elongations will be in the ratio

(a) 2 : 1 (b) 1 : 4 (c) 1 : 8 (d) 8 : 1.

19. A body floats with one third of its volume outside water and 3/4 of its volume outside another liquid. The density of the other liquid is

(a) 9/4 g/c.c. (b) 4/2 g/c.c.
(c) 8/3 g/c.c. (d) 3/8 g/c.c.

20. Two cylinders A and B float on water. It is observed that A floats with 2/3rd of its volume immersed and B floats with half of its volume immersed. The ratio of densities of A and B is

(a) 4 : 3 (b) 3 : 1 (c) 3 : 2 (d) 3 : 4.

21. Two spheres are made of same metal and have same mass. One is solid and the other is hollow. When heated to the same temperature, percentage increase in diameter will be

(a) more for hollow sphere
(b) less for hollow sphere
(c) same for both (d) cannot say.

22. The coefficient of linear expansion of a crystal in one direction is α_1 and that in every direction perpendicular to it is α_2. The coefficient of cubical expansion is

(a) $3\alpha_1$ (b) $3\alpha_2$
(c) $\alpha_1 + 2\alpha_2$ (d) $2\alpha_1 + \alpha_2$.

23. In a pressure cooker, cooking is faster because the increase of vapour pressure

(a) increases specific heat
(b) decreases specific heat
(c) decreases boiling point
(d) increases the boiling point.

24. An ideal gas A and a real gas B have their volumes increased from V to $2V$ under isothermal conditions. The increase in internal energy

(a) of A will be more than B
(b) of A will be less than B
(c) will be same in both cases
(d) will be zero in both cases.

25. When the door of a refrigerator in a room is kept open, the temperature of the room

(a) decreases (b) increases
(c) remains constant (d) cannot say.

26. Water falls from a height of 500 m. What is the rise in temperature of water at the bottom if whole energy is used up in heating water?

(a) 0.96°C (b) 1.02°C
(c) 1.16°C (d) 0.23°C.

27. The kinetic energy of one mole of an ideal gas is $E = 3/2\ RT$. Then C_P will be

(a) $0.5R$ (b) $0.1R$ (c) $1.5R$ (d) $2.5R$.

28. During the melting of a slab of ice at 273 K at atmospheric pressure,

(a) positive work is done by the ice water system on the atmosphere
(b) positive work is done on the ice water system by the atmosphere
(c) internal energy of ice water system remain constant
(d) internal energy of ice water system decreases.

29. Heat given to a body which raises its temperature by 1°C is
(a) water equivalent (b) specific heat
(c) thermal capacity (d) temperature gradient.

30. A black body has maximum wavelength λ_m at 2000 K. Its corresponding wavelength at 3000 K will be
(a) $\frac{3}{2}\lambda_m$ (b) $\frac{2}{3}\lambda_m$ (c) $\frac{16}{81}\lambda_m$ (d) $\frac{81}{16}\lambda_m$

31. A cylindrical rod is having temperature T_1 and T_2 at its ends. The rate of flow of heat is Q_1 cal/sec. If all the linear dimensions are doubled keeping temperatures constant, then the rate of flow of heat Q_2 will be
(a) $4Q_1$ (b) $2Q_1$ (c) $Q_1/4$ (d) $Q_1/2$.

32. Two spheres made of same material have radii in the ratio 1 : 2. Both are at same temperature. Ratio of heat radiation energy emitted per second by them is
(a) 1 : 2 (b) 1 : 4 (c) 1 : 8 (d) 1 : 16.

33. Consider a compound slab consisting of two different materials having equal thickness and thermal conductivities K and $2K$ respectively. The equivalent thermal conductivity of the slab is
(a) $\frac{2}{3}K$ (b) $\sqrt{2}K$ (c) $3K$ (d) $\frac{4}{3}K$

34. At absolute zero
(a) all substances exist in solid form
(b) molecular motion ceases
(c) water becomes ice (d) none of these.

35. Of the following, the equation of plane progressive wave is
(a) $y = r\sin\omega t$ (b) $y = r\sin(\omega t - kx)$
(c) $y = \frac{a}{\sqrt{r}}\sin(\omega t - kx)$ (d) $y = \frac{a}{r}\sin(\omega t - kx)$

36. When a sound wave goes from one medium to another, the quantity that remains unchanged is
(a) frequency (b) amplitude
(c) wavelength (d) speed.

37. A plane wave of sound travelling in air is incident upon a plane water surface. The angle of incidence is 30°. If the velocity of sound in water is 1400 m/s, and the velocity of sound in air is 330 m/s, there will be
(a) reflection only (b) refraction only
(c) both reflection and refraction
(d) neither reflection nor refraction.

38. If the intensities of two interfering waves be I_1 and I_2, the contrast between maximum and minimum intensity is maximum, when
(a) $I_1 >> I_2$ (b) $I_1 << I_2$
(c) $I_1 = I_2$ (d) either I_1 or I_2 is zero.

39. A number of tuning forks are arranged in order of increasing frequency and any two successive forks produce 4 beats per sec, when sounded together. If the last tuning fork has a frequency octave higher than that of the first fork is 256 Hz, then the number of tuning forks is
(a) 63 (b) 64 (c) 65 (d) 66.

40. Two waves of length 100 cm and 101 cm produce 10 beats in 3 sec. The speed of sound is approximately
(a) 1010 m/s (b) 355 m/s
(c) 336.67 m/s (d) 33.67 m/s.

41. The velocities of sound at the same temperature in two monoatomic gases of densities ρ_1 and ρ_2 are v_1 and v_2 respectively. If $\rho_1/\rho_2 = 4$, then the value of v_1/v_2 is
(a) 1/4 (b) 2 (c) 1/2 (d) 4.

42. The displacement of a wave travelling in x-direction is given by $y = 10^{-4}\sin(600t - 2x + \pi/3)$ where x and y are in metre and t is in second. The speed of wave motion in ms^{-1} is
(a) 300 (b) 600 (c) 1200 (d) 200.

43. Quality of sound depends upon
(a) frequency (b) amplitude
(c) overtones (d) none of these.

44. A particle undergoes simple harmonic motion having time period T. The time taken in $3/8^{th}$ oscillation is
(a) $\frac{3}{8}T$ (b) $\frac{5}{8}T$ (c) $\frac{5}{12}T$ (d) $\frac{7}{12}T$.

45. The graph between the length and the (time period)^2 of a simple pendulum is
(a) straight line (b) circle
(c) parabola (d) hyperbola.

46. A simple pendulum of length l has been set up inside a railway wagon sliding down a frictionless inclined plane having an angle of inclination $\theta = 30°$ with the horizontal. What will be its period of oscillation as recorded by an observer inside the wagon?
(a) $2\pi\sqrt{\frac{2l}{\sqrt{3}g}}$ (b) $2\pi\sqrt{\frac{2l}{g}}$

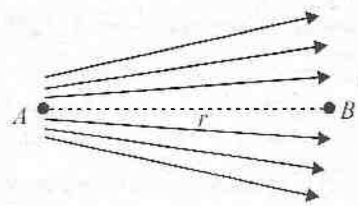
(c) $2\pi\sqrt{\frac{l}{g}}$ (d) $2\pi\sqrt{\frac{\sqrt{3}l}{2g}}$

47. A large horizontal surface moves up and down in simple harmonic motion with an amplitude of 1 cm. If a mass of 1 kg (which is placed on the surface) is to remain continuously in contact with it, the maximum frequency of simple harmonic motion will be
(a) 5 Hz (b) 0.5 Hz (c) 1.5 Hz (d) 10 Hz.

48. For a particle executing simple harmonic motion which of the following statements is not correct?
(a) Total energy of the particle always remains the same.
(b) Restoring force is always directed towards a fixed point.
(c) Restoring force is maximum at the extreme positions.
(d) Acceleration of the particle is maximum at the equilibrium position.

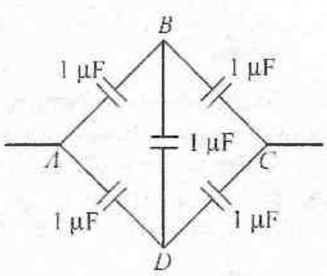
49. Two spheres A and B of exactly same mass are given equal positive and negative charges respectively. Their masses after charging
(a) remains unaffected
(b) mass of A > mass of B
(c) mass of A < mass of B
(d) nothing can be said.

50. Figure shows the electric lines of force emerging from a charged body. If the electric field at A and B are E_A and E_B respectively and if the displacement between A and B is r, then



(a) $E_A > E_B$ (b) $E_A < E_B$
(c) $E_A = E_B/r$ (d) $E_A = E_B/r^2$.

51. Study figure shown and find out the equivalent capacitance of the network between D and B.



(a) 5 μF
(b) 3 μF
(c) 2 μF
(d) 1 μF.

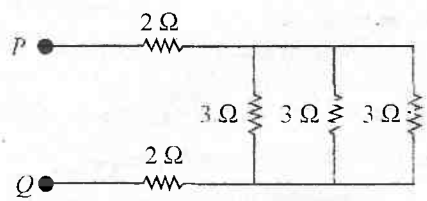
52. Two copper spheres of same radii one hollow and other solid are charged to the same potential then
(a) both will hold same charge
(b) solid will hold more charge
(c) hollow will hold more charge
(d) hollow can not be charged.

53. A capacitor of capacitance 1/300 μF is connected to a battery of 300 V and charged. Then the energy stored in the condenser is
(a) 3×10^{-4} J (b) 6×10^{-14} J
(c) 1.5×10^{-4} J (d) 12×10^{-5} J.

54. A wire 1 m long has a resistance of 1 Ω. If it is uniformly stretched, so that its length increases by 25%, then its resistance will increase by
(a) 25% (b) 50%
(c) 56.25% (d) 77.33%.

55. The resistance of a metal conductor increases with temperature due to
(a) change in current carriers
(b) change in the dimensions of the conductor
(c) increase in the number of collisions among the current carriers
(d) increase in the rate of collisions between the current carriers and the vibrating atoms of the conductor.

56. What will be the resistance between P and Q in the following circuit?



(a) (1/3) Ω (b) (2/3) Ω (c) 2 Ω (d) 5 Ω.

57. To get the maximum current from a parallel combination of n identical cells each of internal resistance r in an external resistance R, when
(a) $R >> r$ (b) $R << r$
(c) $R = r$ (d) none of these.

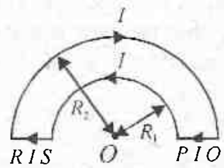
58. Two electric bulbs, one 200 volt-60 watt and the other of 200 volt-200 watt are connected in series of a 200 volt line, then
(a) the potential drop across the two bulbs is the same
(b) the potential drop across the 60 watt bulb is greater than the potential drop across the 200 watt bulb
(c) the potential drop acrosss the 200 watt bulb is greater than the 60 watt bulb
(d) the potential drop across both the bulbs is 200 volts.

59. Inversion temperature of a thermocouple is that temperature of hot junction at which the e.m.f is
(a) maximum (b) minimum
(c) zero (d) none of these.

60. Which of the following thermocouple produces the maximum thermo e.m.f. for the same temperature difference between hot and cold junctions?
(a) copper-bismuth (b) antimony-bismuth
(c) iron-nickel (d) copper-iron.

61. When a straight conductor is carrying an electric current
(a) there are circular magnetic lines of force around it
(b) there are no magnetic lines of force near it
(c) there are magnetic lines of force parallel to conductor along the direction of current
(d) there are magnetic lines of force parallel to conductor opposite to the direction of current.

62. The wire loop $PQRS$ formed by joining two semi circular wires of radii R_1 and R_2 carries a current I as shown. The magnitude of magnetic induction at the centre C is



(a) $\frac{\mu_0 I}{4}\left(\frac{R_1}{R_2}-\frac{1}{R_1}\right)$ (b) $\frac{\mu_0 I}{4}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$
(c) $\mu_0 I\left(\frac{1}{R_2}-\frac{1}{R_1}\right)$ (d) $\mu_0 I\left(\frac{1}{R_1}\right)$

63. A circular loop of area 0.02 m^2 carrying a current of 10 A, is held with its plane perpendicular to a magnetic field induction 0.2 T. The torque acting in the loop is
(a) 0.01 Nm (b) 0.001 Nm
(c) zero (d) 0.8 Nm.

64. Two parallel long wires A and B carry currents I_1 and I_2 ($< I_1$). When I_1 and I_2 are in the same direction, the magnetic field at a point mid way between the wires is 10 μT. If I_2 is reversed, the field becomes 30 μT. The ratio I_1/I_2 is
(a) 1 (b) 2 (c) 3 (d) 4.

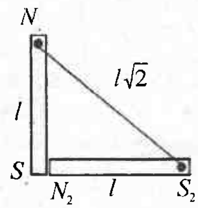
65. The deflection in moving coil galvanometer is reduced to half, when it is shunted with a 40 Ω coil. The resistance of the galvanometer is
(a) 60 Ω (b) 10 Ω (c) 40 Ω (d) 20 Ω.

66. In a shunted ammeter, only 10% of current passes through the galvanometer of resistance G. The resistance of the shunt is
(a) $9G$ (b) $10G$ (c) $G/9$ (d) $G/10$.

67. The magnetic field at the centre of current I carrying loop of radius r is
(a) $\frac{\mu_0 nI}{2r}$ (b) $\frac{\mu_0 nI}{2\pi r}$ (c) $\frac{\mu_0 nI}{r}$ (d) $\mu_0 nI$.

68. A magnet is broken into three pieces in length. The strength of the new pole is .... the strength of the poles of original magnet.
(a) the same as (b) one half
(c) double (d) one third.

69. Two identical thin bar magnets each of length l and pole strength m are placed at right angles to each other, with north pole of one touching south pole of the other, then the magnetic moment of the system is



(a) $1ml$ (b) $2ml$ (c) $\sqrt{2}ml$ (d) $ml/2$.

70. Two short magnets of equal magnetic moments are placed on a piece of cork which floats on water. The magnets are so placed that the axis of one produced bisects the axis of the other at right angles. Then the cork
(a) moves bodily only (b) rotates only
(c) has neither rotational nor translational motion
(d) has rotational as well as translational motion.

71. A ferromagnetic material is heated above its Curie temperature. Which one is correct statement?
(a) ferromagnetic domains are perfectly arranged
(b) ferromagnetic domains become random
(c) ferromagnetic domains are not influenced
(d) ferromagnetic material changes into diamagnetic substances.

72. Most of the substances show which of the magnetic property?
(a) diamagnetism (b) paramagnetism
(c) ferromagnetism (d) none of these.

73. A material is placed in a magnetic field and it is thrown out of it. Then the material is
(a) paramagnetic (b) diamagnetic
(c) ferromagnetic (d) non-magnetic.

74. A bar magnet of magnetic moment M is kept in a uniform magnetic field of strength B, making angle θ with its direction. The torque acting on it is
(a) MB (b) $MB\cos\theta$
(c) $MB(1-\cos\theta)$ (d) $MB\sin\theta$.

75. Magnetic flux ϕ in weber in a closed circuit of resistance 10 Ω varies with time t (sec) as $\phi = 6t^2 - 5t + 1$. The magnitude of induced current at $t = 0.25$ is

(a) 0.2 A (b) 0.6 A (c) 1.2 A (d) 0.8 A.

76. Alternating voltage $V = 400\sin(500\pi t)$ is applied across a resistance of 0.2 kΩ. The r.m.s. value of current will be equal to

(a) 14.14 A (b) 1.414 A
(c) 0.1414 A (d) 2.0 A.

77. What changes on polarisation of light ?

(a) frequency (b) wavelength
(c) phase (d) intensity.

78. A concave mirror of focal length f produces an image n times the size of object. If image is real, then distance of object from mirror is

(a) $(n-1)f$ (b) $\left(\frac{n-1}{n}\right)f$
(c) $\left(\frac{n+1}{n}\right)f$ (d) $(n+1)f$.

79. A convex mirror is used to form an image of a real object. Choose the wrong statement.

(a) the image lies between the pole and the focus
(b) the image is diminished in size
(c) the image is erect (d) the image is real.

80. If an object is 30 cm away from a concave mirror of focal length 15 cm, the image will be

(a) erect (b) virtual
(c) diminished (d) of same size.

81. A fish 10 cm long is 4 cm under the water level. Its length when viewed vertically above will be

(a) 10 cm (b) 3 cm (c) 7.5 cm (d) 8 cm.

82. A ray of light passes from vacuum into a medium of refractive index μ, the angle of incidence is found to be twice the angle of refraction. Then the angle of incidence is

(a) $\cos^{-1}(\mu/2)$ (b) $2\cos^{-1}(\mu/2)$
(c) $2\sin^{-1}(\mu)$ (d) $2\sin^{-1}(\mu/2)$.

83. The astronomical telescope consists of objective and eye-piece. The focal length of the objective is

(a) equal to that of the eye piece
(b) greater than that of eye piece
(c) shorter than that of eye piece
(d) five times shorter than that of the eye piece.

84. Rainbow is formed due to a combination of

(a) refraction and absorption
(b) dispersion and focussing
(c) refraction and scattering
(d) dispersion and total internal reflection.

85. Why sun has elliptical shape when it rises and sets? It is due to

(a) refraction (b) reflection
(c) scattering (d) dispersion.

86. The image formed by an objective of a compound microscope is

(a) virtual and diminished
(b) real and diminished
(c) real and enlarged (d) virtual and enlarged.

87. In which of the following case, man will not see image greater than himself?

(a) concave mirror (b) convex mirror
(c) plane and concave (d) none of these.

88. A photographer changes the aperture of his camera so that the new diameter of the aperture is twice the initial one. The ratio of new exposure time to the initial one is

(a) 1 : 2 (b) 2 : 1 (c) 1 : 4 (d) 4 : 1.

89. The ratio of specific charge of ionic deuterium to that of proton will be

(a) 4 : 1 (b) 2 : 1 (c) 1 : 4 (d) 1 : 2.

90. The energy of a photon in electron volt, whose wavelength is 6600 Å is ($h = 6.6 \times 10^{-34}$ Js)

(a) 0.1875 eV (b) 1.875 eV
(c) 18.75 eV (d) 198 eV.

91. A photocell with a constant potential difference of V volt across it is illuminated by a point source from a distance of 25 cm. When the source is moved to a distance of 1 m, the electrons emitted by the photocell

(a) carry $1/4^{th}$ their previous energy
(b) are $1/16^{th}$ as numerous as before
(c) are $1/4^{th}$ as numerous as before
(d) carry $1/4^{th}$ their pervious momentum.

92. The work function for tungsten and sodium are 4.5 eV and 2.3 eV respectively. If the threshold wavelength λ for sodium is 5460 Å, the value of λ for tungsten is

(a) 528 Å (b) 2791 Å
(c) 5893 Å (d) 10683 Å.

93. The wavelength of characteristic X-rays depends upon

(a) temperature of target (b) size of target
(c) atomic number of target
(d) mass of target.

94. What determined the hardness of the X-rays obtained from the Coolidge tube?
(a) current in the filament
(b) pressure of air in the tube
(c) nature of target
(d) potential difference between cathode and target.

95. Light of certain wavelength and intensity ejects photoelectrons from a metal plate. Then this beam is replaced by another beam of smaller wavelength and smaller intensity. As a result
(a) no change occurs
(b) emission of photoelectrons stops
(c) kinetic energy of photoelectrons decreases by the strength of the photoelectric current increase
(d) kinetic energy of photoelectrons increases but the strength of the photoelectric current decreases.

96. What is used to convert alternating current into a direct current?
(a) choke coil (b) transformer
(c) diode valve (d) triode valve.

97. The value of plate resistance of a triode is $3 \times 10^3\ \Omega$ and its mutual conductance factor is 1.5 millimho, then its amplification factor will be
(a) 2×10^6 (b) 45
(c) 4.5 (d) 4×10^{-5}.

98. A silicon specimen is made into a p-type semiconductor by doping, on an average, one indium atom per 5×10^7 silicon atoms. If the number density of atoms in the silicon specimen is 5×10^{28} atoms/m^3, then the number of acceptor atoms in silicon per cubic centimeter will be
(a) 2.5×10^{30} atoms/cm^3
(b) 2.5×10^{35} atoms/cm^3
(c) 1.0×10^{13} atoms/cm^3
(d) 1.0×10^{15} atoms/cm^3.

99. In a good conductor, the energy gap between the conduction band and the valence band is
(a) infinity (b) wide
(c) narrow (d) zero.

100. On increasing the reverse voltage in a p-n junction diode the value of reverse current will
(a) gradually increase (b) suddenly increase
(c) remain constant (d) gradually decrease.

ANSWERS

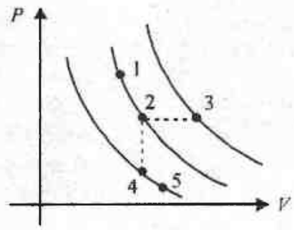
1. (c)	2. (d)	3. (b)	4. (d)	5. (b)
6. (a)	7. (b)	8. (b)	9. (a)	10. (a)
11. (d)	12. (a)	13. (c)	14. (b)	15. (d)
16. (d)	17. (b)	18. (c)	19. (c)	20. (a)
21. (c)	22. (c)	23. (d)	24. (d)	25. (b)
26. (c)	27. (d)	28. (b)	29. (c)	30. (b)
31. (b)	32. (b)	33. (d)	34. (b)	35. (b)
36. (a)	37. (a)	38. (c)	39. (c)	40. (c)
41. (c)	42. (a)	43. (c)	44. (c)	45. (a)
46. (a)	47. (a)	48. (d)	49. (c)	50. (a)
51. (c)	52. (a)	53. (c)	54. (c)	55. (d)
56. (d)	57. (b)	58. (b)	59. (c)	60. (b)
61. (a)	62. (b)	63. (c)	64. (b)	65. (c)
66. (c)	67. (a)	68. (a)	69. (c)	70. (c)
71. (b)	72. (a)	73. (b)	74. (d)	75. (a)
76. (b)	77. (d)	78. (c)	79. (d)	80. (d)
81. (a)	82. (b)	83. (b)	84. (d)	85. (a)
86. (c)	87. (b)	88. (c)	89. (d)	90. (b)
91. (b)	92. (b)	93. (c)	94. (d)	95. (d)
96. (c)	97. (c)	98. (d)	99. (d)	100. (b)

SAMPLE PAPER FOR IIT-JEE 2006

Based on *New pattern*

(For Q.NO. 1 to 40) Only one option is correct and there will be negative marking in these questions.

1. A certain gas is taken to the five states represented by dots in the graph. The plotted lines are isotherms. Order of the most probable speed v_p of the molecules at these five states is

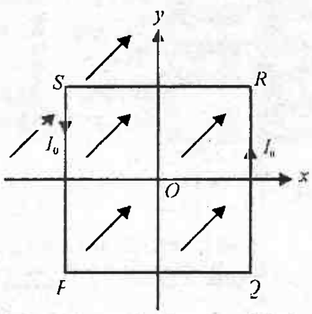


(a) $v_{p \text{ at } 3} > v_{p \text{ at } 1} = v_{p \text{ at } 2} > v_{p \text{ at } 4} = v_{p \text{ at } 5}$
(b) $v_{p \text{ at } 1} > v_{p \text{ at } 2} = v_{p \text{ at } 3} > v_{p \text{ at } 4} = v_{p \text{ at } 5}$
(c) $v_{p \text{ at } 3} > v_{p \text{ at } 2} = v_{p \text{ at } 4} > v_{p \text{ at } 1} = v_{p \text{ at } 5}$
(d) insufficient information to predict the result.

2. On an X temperature scale, water freezes at $-125.0°X$ and boils at $375.0°X$. On a Y temperature scale, water freezes at $-70.0°Y$ and boils at $-30.0°Y$. The value of temperature on X-scale equal to the temperature of $50.0°Y$ on Y-scale is

(a) $455.0°X$ (b) $-125.0°X$
(c) $1375.0°X$ (d) $1500.0°X$.

3. A uniform, constant magnetic field $\vec{B}$ is directed at an angle of 45° to the x-axis in the xy-plane, $PQRS$ is a rigid square wire frame carrying a steady current I_0, with its centre at the origin O. At time $t = 0$, the frame is at rest in the position shown in figure, with its sides parallel to the x and y-axes. Each side of the frame is of mass M and length L. The torque $\vec{\tau}$ about O acting on the frame due to the magnetic field will be

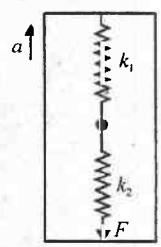


(a) $\tau = \frac{BI_0L^2}{\sqrt{2}}(-\hat{i} + \hat{j})$ (b) $\vec{\tau} = \frac{BI_0L^2}{\sqrt{2}}(\hat{i} - \hat{j})$
(c) $\vec{\tau} = \frac{BI_0L^2}{\sqrt{2}}(\hat{i} + \hat{j})$ (d) $\vec{\tau} = \frac{BI_0L^2}{\sqrt{2}}(-\hat{i} - \hat{j})$

4. The coefficient of viscosity η of a liquid is defined as the tangential force on a layer in that liquid per unit area per unit velocity gradient across it. Then a sphere of radius a moving through it under a constant force F attains a constant velocity v given by (where K is a numerical constant)

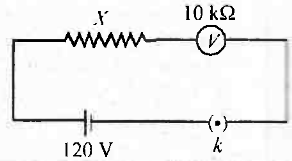
(a) $KFa\eta$ (b) $K\frac{F}{a}\eta$
(c) $K\frac{F}{a\eta}$ (d) $K\eta\frac{a}{F}$

5. When force F is applied to the combination of two springs (shown in figure), the elongation in upper spring will be (the whole system is inside a lift is moving upwards with a constant acceleration a). The upper spring is ideal while the lower spring has mass M. Assume that the deformation of the springs are constant.



(a) $\frac{M(g+a)}{k_1+k_2}$
(b) $\frac{[F+M(g+a)](k_1+k_2)}{k_1k_2}$
(c) $\frac{(F+M(g+a))}{k_1+k_2}$ (d) $\frac{F+Mg+Ma}{k_1}$.

6. A D.C. supply of 120 V is connected to a large resistance X. A voltmeter of resistance 10 kΩ placed in series in



Contributed by Deptt. of Physics, **Resonance**, Kota (Rajasthan)

the circuit reads 4 V. This is an unusual use of voltmeter for measuring very high resistance. The value of X is

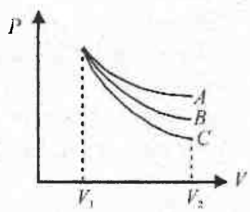
(a) 390 kΩ (b) 290 kΩ
(c) 190 kΩ (d) 300 kΩ.

7. Select the correct characteristics of the image of a real object formed by a lens of focal length f from the choices given below?

Nature of lens and position	Characteristic of the image observed
(i) Lens is converging and $2f$ away from the object	(A) virtual, erect, diminished
(ii) Lens is converging and between f and $2f$ from the object	(B) virtual, erect, magnified
(iii) Lens is diverging and distant f from the object	(C) real, inverted, diminished
(iv) Lens is converging and less than f from the object	(D) real, inverted, magnified
	(E) real, inverted, same size.

(a) (ii) - C (b) (iii) - B
(c) (i) - E (d) (iv) - A.

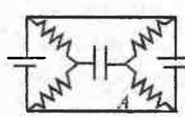
8. An ideal gas undergoes an expansion from a state with temperature T_1 and volume V_1 to V_2 through three different polytropic processes A, B and C as shown in the P-V diagram.



If $|\Delta E_A|$, $|\Delta E_B|$ and $|\Delta E_C|$ be the magnitude of changes in internal energy along the three paths respectively, then

(a) $|\Delta E_A| < |\Delta E_B| < |\Delta E_C|$ if temperature in every process decreases
(b) $|\Delta E_A| = |\Delta E_B| = |\Delta E_C|$ if temperature in every process decreases
(c) $|\Delta E_A| < |\Delta E_B| < |\Delta E_C|$ if temperature in every process increases
(d) $|\Delta E_B| < |\Delta E_A| < |\Delta E_C|$ if temperature in every process increases.

9. Each resistor in the following circuit has a resistance of 2 MΩ and the capacitors have capacitances of 1 μF. The battery voltage is 3 V. The voltage across the resistor A in the following circuit at steady state is

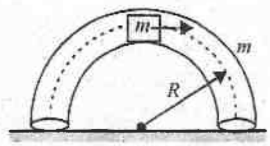


(a) 0 V (b) 0.5 V (c) 0.75 V (d) 1.5 V.

10. One end of a light rod of length 1 m is attached with a string of length 1 m. Other end of the rod is attached at point O such that rod can move in a vertical circle. Other end of the string is attached with a block of mass 2 kg. The minimum velocity that must be given to the block in horizontal direction so that it can complete the vertical circle is (g = 10 m/s^2).

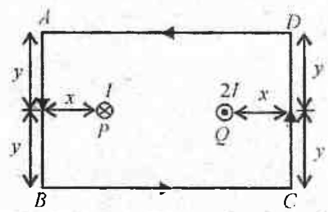
(a) $4\sqrt{5}$ (b) $5\sqrt{5}$
(c) 10 (d) $3\sqrt{5}$.

11. In a vertical plane inside a smooth hollow thin tube a block of same mass as that of tube is released as shown in figure. When it is slightly disturbed it moves towards right. By the time the block reaches the right end of the tube then the displacement of the tube will be (where R is mean radius of tube). Assume that the tube remains in vertical plane.



(a) $2R/\pi$ (b) $4R/\pi$ (c) $R/2$ (d) R.

12. Let B_P and B_Q be the magnetic field produced by the wire P and Q which are placed symmetrically in a rectangular loop $ABCD$ as shown in figure. Current in wire P is I directed inward and in Q is $2I$ directed outwards. If



$\int_A^B \vec{B}_Q \cdot d\vec{l} = 2\mu_0$ tesla meter, $\int_B^A \vec{B}_P \cdot d\vec{l} = -2\mu_0$ tesla meter,

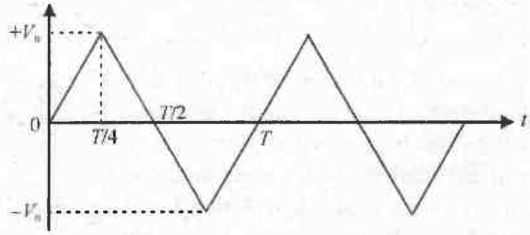
and $\int_A^B \vec{B}_P \cdot d\vec{l} = -\mu_0$ tesla meter, the value of I will be

(a) 8 A (b) 4 A
(c) 5 A (d) 6 A.

13. A ray of light is incident on a face of equilateral triangle at an incident angle 50°. At this angle minimum deviation occurs. This deviation is

(a) 30° (b) 40°
(c) 50° (d) 20°.

14. The voltage time (V - t) graph for triangular wave having peak value V_0 is as shown in figure.



The r.m.s value of V in time interval from $t = 0$ to $T/4$ is

(a) $\frac{V_0}{\sqrt{3}}$ (b) $\frac{V_0}{2}$

(c) $\frac{V_0}{\sqrt{2}}$ (d) none of these.

15. In the above question the average value of voltage (V) in one time period will be

(a) $\frac{V_0}{\sqrt{3}}$ (b) $\frac{V_0}{2}$

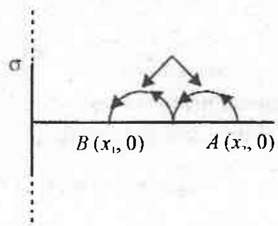
(c) $\frac{V_0}{\sqrt{2}}$ (d) zero.

16. An uncharged parallel plate capacitor is connected to a battery. The electric field between the plates is 10 V/m. Now a dielectric of dielectric constant 2 is inserted between the plates filling the entire space. The electric field between the plates now is

(a) 5 V/m (b) 20 V/m

(c) 10 V/m (d) none of these.

17. An infinite long plate has surface charge density σ as shown in the figure. A point charge q is moved from A to B. Network done by electric field is

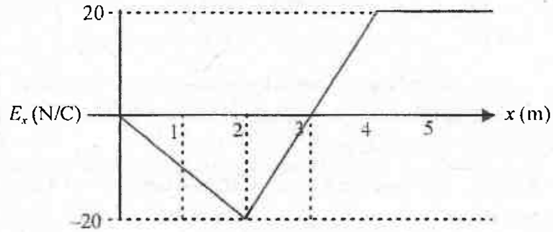


(a) $\frac{\sigma q}{2\varepsilon_0}(x_1 - x_2)$

(b) $\frac{\sigma q}{2\varepsilon_0}(x_2 - x_1)$ (c) $\frac{\sigma q}{\varepsilon_0}(x_2 - x_1)$

(d) $\frac{\sigma q}{\varepsilon_0}(2\pi r + r)$

18. A graph of the x-component of the electric field as a function of x in a region of space is shown. The y and z components of the electric field are zero in this region. If the electric potential is 10 V at the origin, then potential at $x = 2.0$ m is



(a) 10 V (b) 40 V

(c) – 10 V (d) 30 V.

19. A steady current is passing through a linear conductor of non-uniform cross-section. The net quantity of charge crossing any cross-section per second is

(a) directly proportional to the area of cross-section
(b) inversely proportional to the area of cross-section
(c) independent of the area of cross-section
(d) directly proportional to the length of the conductor.

20. When an uncharged parallel plate capacitor is connected to a source of constant potential difference, which of the following is incorrect?

(a) all the charge drawn from the source is stored in the capacitor
(b) all the energy drawn from the source is stored in the capacitor
(c) the potential difference across the capacitor grows rapidly initially and this rate decreases to zero eventually
(d) only half of the energy drawn from the source is dissipated outside the capacitor.

21. In a photoelectric effect, electrons are emitted

(a) with a maximum velocity proportional to the frequency of the incident radiation
(b) at a rate that is independent of the intensity of the incident radiation
(c) only if the frequency of the incident radiation is above a certain threshold value
(d) only if the temperature of the emitter is high.

22. Which one of the following combinations of radioactive decay results in the formation of an isotope of the original nucleus? (assume that beta means β^-)

(a) one alpha and four beta
(b) one alpha and two beta
(c) one alpha and one beta
(d) two alpha and one beta.

23. A uniform rod of mass m and length l is rotating with constant angular velocity ω about an axis which passes through its one end and perpendicular to the length of rod. The area of cross-section of the rod is A and its Young's modulus is Y. Neglect gravity. The strain at the mid point of the rod is

(a) $\frac{m\omega^2 l}{8AY}$ (b) $\frac{3m\omega^2 l}{8AY}$

(c) $\frac{3m\omega^2 l}{4AY}$ (d) $\frac{m\omega^2 l}{4AY}$

24. A solid spherical black body of radius r and uniform mass distribution is in free space. It emits power P and its rate of cooling is R, then

(a) $RP \propto r^2$ (b) $RP \propto r$

(c) $RP \propto 1/r^2$ (d) $RP \propto 1/r$.

25. A black body emits radiation at the rate P when its temperature is T. At this temperature the wavelength at which the radiation has maximum intensity is λ_0. If at another temperature T' the power radiated is P' and wavelength at maximum intensity is $\lambda_0/2$ then

(a) $P'T' = 32PT$ (b) $P'T' = 16PT$

(c) $P'T' = 8PT$ (d) $P'T' = 4PT$.

26. The emissive power of a black body at $T = 300$ K is 100 watt/m^2. Consider a body B of area $A = 10$ m^2 coefficient of reflectivity $r = 0.3$ and coefficient of transmission $t = 0.5$. Its temperature is 300 K. Then which of the following is incorrect?

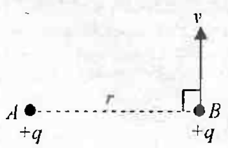
(a) the emissive power of B is 20 W/m^2

(b) the emissive power of B is 200 W/m^2

(c) the power emitted by B is 200 watts

(d) the emissivity of B is 0.2.

27. In the figure shown, A is a fixed charged. B (of mass m) is given by a velocity v perpendicular to line AB. At this moment the radius of curvature of the resultant path of B is



(a) 0 (b) ∞ (infinity)

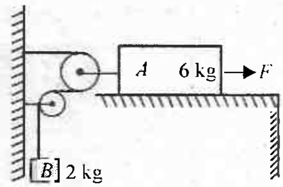
(c) $\frac{4\pi\varepsilon_0 r^2 mv^2}{q^2}$ (d) r.

28. Two cars A and B are travelling towards each other on a single-lane road at 24 m/s and 21 m/s respectively. They notice each other when 180 m apart and apply brakes simultaneously. They just succeed in avoiding collision, both stopping simultaneously at the same position. Assuming constant retardation for each car, the distance travelled by car A while slowing down is

(a) 96 m (b) 84 m

(c) 67 m (d) 113 m.

29. The system starts from rest and A attains a velocity of 5 m/s after it has moved 5 m towards right. Assuming the arrangement to be frictionless everywhere and pulley and strings to be light, the value of the force F applied on A is



(a) 50 N (b) 75 N

(c) 100 N (d) 96 N.

30. When beats are produced by two progressive waves of nearly the same frequency, which one of the following is correct?

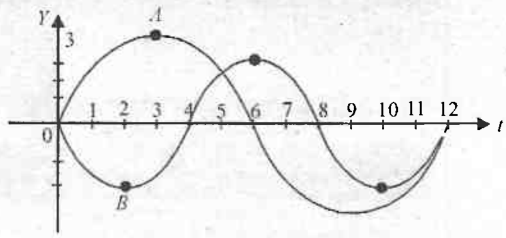
(a) the particles vibrate simple harmonically, with the frequency equal to the difference in the component frequencies

(b) the amplitude of vibration at any point changes simple harmonically with a frequency equal to the difference in the frequencies of the two waves

(c) the frequency of beats depends upon the position, where the observer is

(d) the frequency of beats changes as the time progresses.

31. The displacement *vs* time graph for two waves A and B which travel along the same string as shown in the figure. Their intensity ratio I_A/I_B is

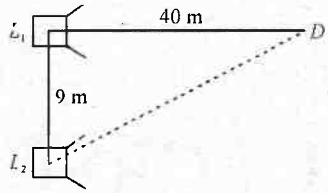


(a) $\frac{9}{4}$ (b) 1

(c) $\frac{81}{16}$ (d) $\frac{3}{2}$.

32. Two loudspeakers L_1, L_2 driven by a common oscillator and amplifier, are set up as shown in the

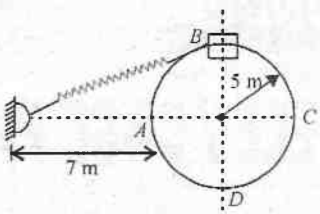
figure. As the frequency of the oscillator increases from zero, the detector at D recorded a series of maximum and minimum signals.



What is the frequency at which the first maximum is observed? (speed of sound = 330 m/s).

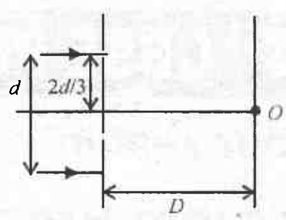
(a) 165 Hz (b) 330 Hz
(c) 495 Hz (d) 660 Hz.

33. A collar B of mass 2 kg is constrained to move along a horizontal smooth and fixed circular track of radius 5 m. The spring lying in the plane of the circular track and having spring constant 200 N/m is undeformed when the collar is at A. If the collar starts from rest at B, the normal reaction exerted by the track on the collar when it passes through A is



(a) 360 N (b) 720 N
(c) 1440 N (d) 2880 N.

34. In the figure shown if a parallel beam of white light is incident on the plane of the slits then the distance of the nearest white spot on the screen from O is (assume $d << D$, $\lambda << d$]



(a) 0 (b) $d/2$
(c) $d/3$ (d) $d/6$.

35. In the above question if the light incident is monochromatic and point O is a maxima, then the wavelength of the light incident cannot be

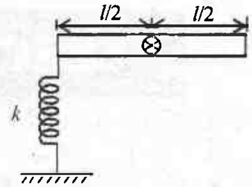
(a) $\frac{d^2}{3D}$ (b) $\frac{d^2}{6D}$
(c) $\frac{d^2}{12D}$ (d) $\frac{d^2}{18D}$.

36. Match the physical quantities given in column I with dimensions expressed in terms of mass M, length L, time T and charge Q given in column II and write the correct answer against the matched quantity.

Column I	Column II
(i) angular momentum	(A) ML^2T^{-2}
(ii) latent heat	(B) ML^2Q^{-2}
(iii) torque	(C) ML^2T^{-1}
(iv) capacitance	(D) $ML^3T^{-1}Q^{-2}$
(v) inductance	(E) $M^{-1}L^{-2}T^2Q^2$
(v) resistivity	(F) L^2T^{-2}

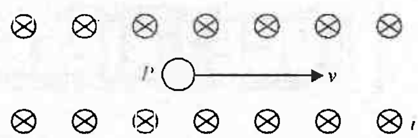
(a) (i) - (C) (b) (ii) - (D)
(c) (iii) - (E) (d) (v) - (F).

37. A uniform rod of mass m and length l is hinged at its mid point in such a way that it can rotate in the vertical plane about a horizontal axis passing through the hinge. One of its ends is attached to a spring of spring constant k which is unstretched when the rod is horizontal. If this rod end is now given a small displacement and released angular frequency of the resulting motion is



(a) $\sqrt{\frac{k}{m}}$ (b) $\sqrt{\frac{2k}{m}}$
(c) $\sqrt{\frac{3k}{m}}$ (d) $\sqrt{\frac{g}{l}}$

38. Two infinite sheets carrying current in same direction (of equal current per unit length K) are separated by a distance d. A proton is released from a point between the plates with a velocity parallel to the sheets but perpendicular to the direction of current in the sheets. Then the path of the proton is



(a) circle (b) helix
(c) straight line
(d) straight line only if it is released from a point exactly midway between the two plates.

39. Two long coaxial and conducting cylinders of radius a and b are separated by a material of conductivity σ and a constant potential difference V is maintained between them, by a battery. Then a current per unit length of the cylinder from one cylinder to the other is

(a) $\frac{4\pi\sigma}{\ln(b/a)}V$ (b) $\frac{4\pi\sigma}{b+a}V$

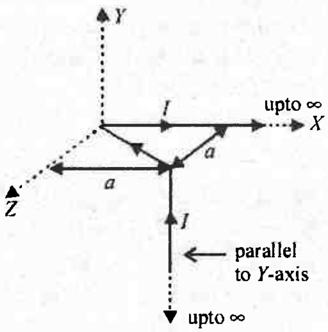
(c) $\frac{2\pi\sigma}{\ln(b/a)}V$ (d) $\frac{2\pi\sigma}{b+a}V$

40. A ring of mass m, radius r having a charge q uniformly distributed over it and free to rotate about its own axis is placed in a region having a magnetic field B is suddenly switched off, the angular velocity acquired by the ring is

(a) $\frac{qB}{m}$ (b) $\frac{2qB}{m}$

(c) $\frac{qB}{2m}$ (d) none of these.

41. The magnetic field at the origin due to the current flowing in the wire is



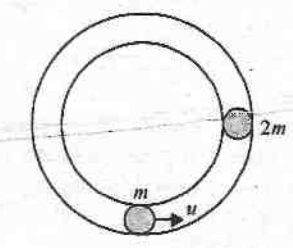
(a) $-\frac{\mu_0 I}{8\pi a}(\hat{i}+\hat{k})$

(b) $\frac{\mu_0 I}{2\pi a}(\hat{i}+\hat{k})$

(c) $\frac{\mu_0 I}{8\pi a}(-\hat{i}+\hat{k})$

(d) $\frac{\mu_0 I}{4\pi a\sqrt{2}}(\hat{i}-\hat{k})$

42. Two masses m and $2m$ are placed in fixed horizontal circular smooth hollow tube as shown. The mass m is moving with speed u and the mass $2m$ is stationary. After their collision, the time elapsed for next collision (coefficient of restitution e = 1/2)



(a) $\frac{2\pi r}{u}$ (b) $\frac{4\pi r}{u}$

(c) $\frac{3\pi r}{u}$ (d) $\frac{12\pi r}{u}$

43. A mosquito with 8 legs stands on water surface and each leg makes depression of radius a. If the surface tension and angle of contact are T and zero respectively, then the weight of mosquito is

(a) $8Ta$ (b) $16\pi Ta$

(c) $Ta/8$ (d) $Ta/16\pi$.

44. The values of kinetic energy K and potential energy U are measured as follows:

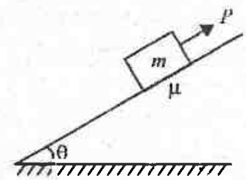
$$K = 100.0 \pm 2.0 \text{ J}$$
$$U = 200.0 \pm 1.0 \text{ J}$$

Then the percentage error in the measurement of mechanical energy is

(a) 2.5% (b) 1%

(c) 0.5% (d) 1.5%.

45. A block of mass m is being pulled up the rough incline by an agent delivering constant power P. The coefficient of friction between the block and the incline is μ. The maximum speed of the block during the course of ascent is



(a) $v = \frac{P}{mg\sin\theta + \mu mg\cos\theta}$

(b) $v = \frac{P}{mg\sin\theta - \mu mg\cos\theta}$

(c) $v = \frac{2P}{mg\sin\theta - \mu mg\cos\theta}$

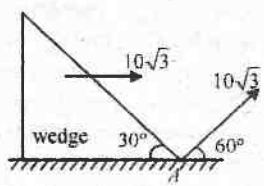
(d) $v = \frac{3P}{mg\sin\theta - \mu mg\cos\theta}$

46. A uniform field $\vec{B} = 3\hat{i} + 4\hat{j} + 5\hat{k}$. A rod of length 5 m is placed along y-axis is moved along x-axis with constant speed 1 m/sec. Then induced e.m.f in the rod will be

(a) zero (b) 25 volt

(c) 20 volt (d) 15 volt.

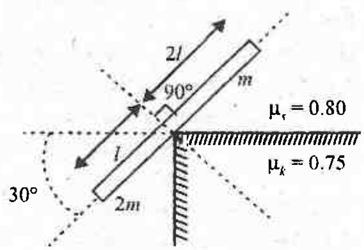
47. A particle is projected at angle 60° with speed $10\sqrt{3}$, from the point A as shown in the figure. At the same time the wedge is made to move with speed $10\sqrt{3}$ towards right as shown in figure. Then the time after which particle will strike with wedge is



(a) 2 sec (b) $2\sqrt{3}$ sec

(c) $4/\sqrt{3}$ sec (d) none of these.

48. As shown in the figure, rod is composed of two parts of $2m$ mass, length l and m mass, length $2l$. It is placed on rough edge as shown in



the figure. In the given configuration of rod
(a) it will slide first, then rotate to fall
(b) it will rotate first, then slide to fall
(c) it will neither slide nor rotate
(d) it will slide and rotate simultaneously.

49. A uniform magnetic field of 1.5 T exists in a cylindrical region of radius 10.0 cm, its direction being parallel to the axis along east to west. A current carrying wire in north south direction passes through this region. The wire intersects the axis and experience a force of 1.2 N downward. If the wire is turned from north to south to north east-south west direction, then magnitude and direction of force is

(a) 1.2 N upward (b) $1.2\times\sqrt{2}$ N downward
(c) 1.2 N (d) $\frac{1.2}{\sqrt{2}}$ N downward

50. In the above problem, if wire in north-south direction is lowered from the axis by a distance of 6 cm, then magnitude and direction of force is
(a) 0.48 N, downward (b) 0.48 N, upward
(c) 0.96 N, downward (d) 0.96 N, upward.

PASSAGE I : Read the following passage and answer the questions numbered 51 to 55. They have only one correct option.

Heat transfer by radiation : When the thermal radiations fall on matter they are either transmitted, absorbed or reflected. The so-called diathermanous materials like dry air, rock salt, carbon-di-sulphide etc. are practically transparent to these radiations. On the other hand materials like metals, wood, water are opaque and therefore, they are known as adiathermanous or athermanous. The thermal radiations can penetrate a diathermanous material. Once radiated by a hot body, thermal radiation travel on and on as electromagnetic waves until they get absorbed by some cold athermanous body.

The total energy reflected R, transmitted T and absorbed A by certain area of the body in a given interval of time must be equal to the total energy I falling on a body over the same area and in the same interval of time, *i.e.* $R + T + A = I$.

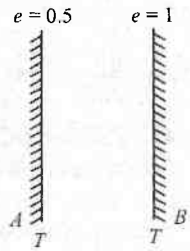
If we define, r reflective power, the fraction of incident radiations reflected, t transmitting power, the fraction of incident radiations transmitted, a absorptive power, the fraction of incident radiations absorbed then from the above. $r + t + a = 1$

A body which is transparent ($t \to 1$) is not opaque and it is not a good reflector ($a \to 0$, $r \to 0$). But if the body is a good absorber ($a \to 1$), it is not transparent and its surface is dull ($t \to 0$, $r \to 0$).

The relation given above is oversimplified, because body may transmit some wavelength and absorb other wavelengths.

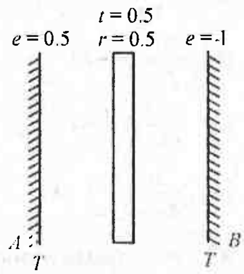
For the next three questions assume that emissions from all surfaces are perpendicular to respective surfaces.

51. For the surface A shown in figure, $e = 0.5$ and for the surface B, $e = 1$. Given that $P = \sigma AT^4 = 100$ J/s. For this situation, rate of loss of energy by the surfaces A and B respectively are : (assume that $t = 0$ for both A and B).



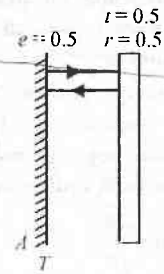
(a) 100 J/s, 50 J/s
(b) 50 J/s, 50 J/s
(c) 0, 50 J/s (d) 0, 0.

52. A slab of transmitting power $t = 0.5$ and reflective power $r = 0.5$ is kept in between the two surfaces as shown. For this situation the rate of loss of energy by the surface A and B respectively are



(a) 25 J/s, 50 J/s
(b) 50 J/s, 100 J/s
(c) 12.5 J/s, 37.5 J/s (d) 0, 0.

53. In the above question, if the surface B is removed, then the rate loss of energy by surface A is



(a) 33.3 J/s
(b) 25 J/s
(c) 50 J/s
(d) 37.5 J/s

54. Four spheres of the same radius of different material A, B, C and D have following data as given in the table. All are at the same temperature. B is the best emitter. Then its transmitivity may be

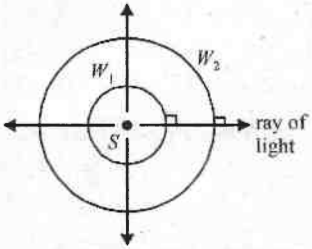
	Reflectivity	**Transmitivity**
A	0.1	0.5
B	0.2	–
C	0.3	0.4
D	0.4	0.2

(a) 0.4 (b) 0.5 (c) 0.2 (d) 0.8

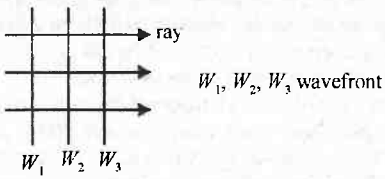
55. To maintain the temperature of inner environment of a box a source of heat is placed inside the box. The power of the source is minimum if the medium surrounding the box used is
(a) either metal or rock salt
(b) either wood or dry air
(c) either water or wood
(d) either metal or car.

PASSAGE 2 : Read the following passage and answer the questions numbered 56 to 60. They have only one correct option.

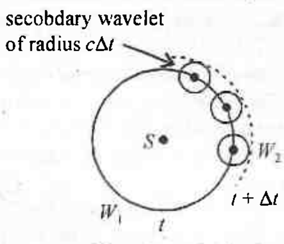
Huygen was the first scientist who proposed the idea of wave theory of light. He said that the light propagates in form of wavefronts. A wavefront is an imaginary surface at every point of which waves are in the same phase. For example the wavefronts for a point source of light is collection of concentric spheres which have centre at the origin. W_1 is a wavefront, W_2 is another wavefront.



The radius of the wavefront at time t is ct in this case where c is the speed of light. The direction of propagation of light is perpendicular to the surface of wavefront. The wavefronts are plane wavefronts in case of a parallel beam of light.



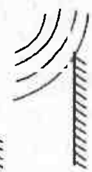
Huygen also said that every point of the wavefront acts as the source of secondary wavelets. The tangent drawn to all secondary wavelets at a time is the new wavefront at that time. The wavelets are to be considered only in the forward direction (*i.e.* the direction of propagation of light) and not in the reverse direction. If a wavefront W_1 at time t is given, then to draw the wavefront at time $t + \Delta t$ take some points on the wavefront W_1 and draw spheres of radius $c\Delta t$. They are called secondary wavelets.

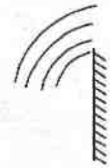
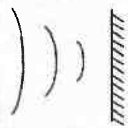
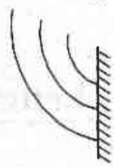
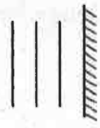


Draw a surface W_2 which is tangential to all these secondary wavelets, W_2 is the wavefront at time $t + \Delta t$. Huygen proved the laws of reflection and laws of refraction using concept of wavefronts.

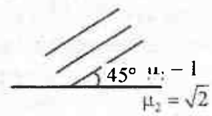
56. A point source of light is placed at origin, in air. The equation of wavefront of the wave at time t, emitted by source at $t = 0$, is (take refractive index of air as 1)
(a) $x + y + z = ct$
(b) $x^2 + y^2 + z^2 = t^2$
(c) $xy + yz + zx = c^2t^2$
(d) $x^2 + y^2 + z^2 = c^2t^2$.

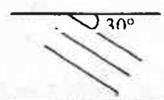
57. Spherical wave fronts shown in figure, strike a plane mirror. Reflected wave fronts will be as shown in

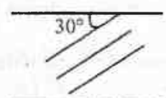


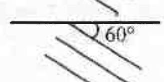
(a) 
(b) 
(c) 
(d) 

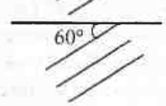
58. Wavefronts incident on an interface between the media are shown in the figure. The refracted wavefronts will be as shown in



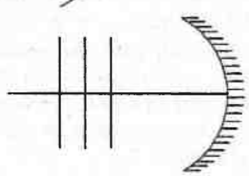
(a) 

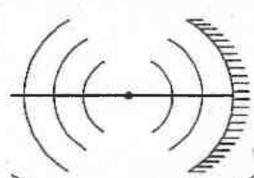
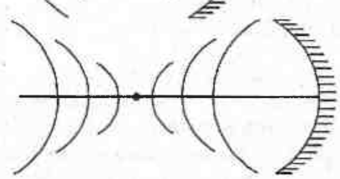
(b) 

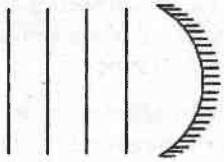
(c) 

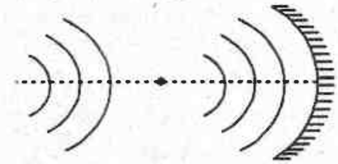
(d) 

59. Plane wavefronts are incident on a spherical mirror as shown. The reflected wavefronts will be

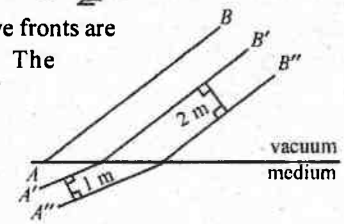


(a) 
(b) 

(c) 

(d) 

60. Certain plane wave fronts are shown in figure. The refractive index of medium is



(a) 2
(b) 4
(c) 1.5
(d) cannot be determined.

ANSWERS

1. (a)	2. (c)	3. (a)	4. (c)	5. (d)
6. (b)	7. (c)	8. (a)	9. (d)	10. (c)
11. (c)	12. (d)	13. (b)	14. (a)	15. (d)
16. (c)	17. (a)	18. (d)	19. (c)	20. (b)
21. (c)	22. (b)	23. (b)	24. (b)	25. (a)
26. (b)	27. (c)	28. (a)	29. (b)	30. (b)
31. (b)	32. (b)	33. (c)	34. (d)	35. (a)
36. (a)	37. (c)	38. (c)	39. (c)	40. (c)
41. (c)	42. (b)	43. (b)	44. (b)	45. (a)
46. (b)	47. (a)	48. (c)	49. (c)	50. (c)
51. (d)	52. (d)	53. (a)	54. (c)	55. (c)
56. (d)	57. (c)	58. (b)	59. (a)	60. (a)

Note : For detailed solutions please log on to our website www.resonance.ac.in

Letter to Editor

Dear Editor,

The enrolment in physics has been steadily decreasing, all over the world, for many years. This is why 2005 was celebrated as the IYP, coinciding with the 100th anniversary of Albert Einstein's Special Relativity. One of the aims of IYP was to improve the public awareness of physics and physics education so as attract young students to physics. As an HSC teacher, I am working on the logical aspects of teaching and learning mechanics - particularly circular motion - for about 30 years and arrived at the following conclusion many years ago which is given below.

Although the logical incompleteness of Newton's laws of motion leads us to Einstein s General Relativity, that incompleteness itself has not been completely understood. This is why we still have problems in teaching/learning 300-year old mechanics. It may be noted that Frank Wilczek [Nobel Laureate of 2004] had admitted, in October. 2004, that he had maximum trouble in learning classical mechanics. He gave a good lesson for physics education and was my subject of lectures in some Indian events of the IYP. Now, some physics organizations are considering the question: Will there be significant rise in the public awareness of physics and in the enrolment in physics? I hesitate to answer positively and in support of this I like to share a unique experience, concerned with a new trend in HSC physics - that is listing Understanding Oriented Questions without giving direct answers to them. Such questions are now attracting promising students like the IIT aspirants.

Let us start with the question on the circular motion. In that question, a body is shown performing the UCM and students have to show directions of centripetal and centrifugal forces, with suitable arrows. Actually, students do know the UCM from std IX and hence, in my opinion, the said question is not very challenging. However, this question - in the reversed manner is much more challenging question. It is like this : The centripetal force is acting on a body, show the direction of motion.

I started the lecture in a Symposium on 16th January 1993 with that reversed question. The minimum academic level of audience was MSc. Physics. But as per my expectation, some young teachers drew anticlockwise trajectory and some did the opposite. Consequently, it was easy for these two groups to understand my opinion about the logical problems in the present treatment of UCM.

If this is the situation with young teachers, having done MSc. in physics, what to talk of HSC students. With such logical problems in the basic concepts of mechanics, one can hardly expect students to jump on physics for making career.

Dileep V. Sathe, Pune

We agree with Dr. Sathe for a need for teaching physics correctly from the grass-roots level by going back to the basic concepts as given by the original authors. Constant interpretations and interpolations of the original ideas have diluted the content of physics. It is the approach to teach science that has to change if students have to learn the correct thinking. We share his concern, as the readers can see from our editorials.. - Editor.

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Very Similar
MODEL TEST PAPER
for AIIMS 2006

Time : 1 hr **Maximum Marks : 60**

Instructions:
1. This question paper contains 60 questions.
2. For every correct answer 1 mark will be credited to your account, 1/3 mark will be deducted for every wrong answer and no marks will be awarded for unattempted questions.
3. Use of Trigonometric table, Calculator or any other helping device is restricted.
4. Useful data : **At.wt./ Mol.wt.** : $KMnO_4$: 158; Cu : 63.5; NaOH : 40; HCl : 36.5; Mg : 24; H : 1; He : 4; C : 12; N : 14; O : 16; Na : 23; P : 31, S : 32; Cl : 35.5; Ca : 40; Zn : 65; Ag : 108.
Atomic No : H : 1; He : 2; Li : 3; Be : 4; B : 5, C : 6; N : 7, O : 8; F : 9; Na : 11; Mg : 12; Al : 13; Si : 14; Fe : 26; Co : 27; Ni : 28; Cu : 29; Zn : 30; Rb : 37
Constants : g = 10m/s^2, R = 8.3 JK^{-1}mol^{-1} or 0.0821 atm lK^{-1}mol^{-1}, $e = 1.6 \times 10^{-19}$ C, $N_0 = 6.023 \times 10^{23}$, $m_p = 1.6 \times 10^{-27}$ kg, $m_e = 9.11 \times 10^{-31}$ kg.
5. Fill in your answers in the given response sheet.

1. An equibiconvex lens of focal length 10 cm is cut by a plane perpendicular to its axis to make two plano convex lenses from it. The focal length of each plano convex lens will be
(a) 5 cm (b) 10 cm
(c) 15 cm (d) 20 cm.

2. A steel wire of uniform area 2 mm^2 is heated upto 50°C and is stretched by tying its two ends rigidly. The change in tension when the temperature falls from 50°C to 30°C is (given $Y = 2.0 \times 10^{11}$ Nm^{-2} and $\alpha = 1.1 \times 10^{-5}$ per °C]
(a) 2.5×10^{10} N (b) 1.5×10^{10} N
(c) 5 N (d) 88 N.

3. An earth satellite moves from an orbit A to another stable lower orbit B. In this process
(a) gravitational potential energy decreases
(b) gravitational potential energy increases
(c) gravitational potential energy remains unchanged
(d) none of these.

4. Two light bulbs one of resistance R and other of resistance r ($< R$) are connected in parallel to the mains. Which bulb glows brighter?
(a) bulb with resistance r
(b) bulb with resistance R
(c) bulb glow equally bright
(d) bulb with resistance r will be fused.

5. In the given reaction,
$_ZX^A \rightarrow {}_{Z+1}Y^A \rightarrow {}_{Z-1}K^{A-4} \rightarrow {}_{Z-1}K^{A-4}$.
Radioactive radiations are emitted in the sequence
(a) β, γ, α (b) α, β, γ
(c) β, α, γ (d) γ, α, β.

6. A system undergoing simple harmonic motion must possess
(a) inertia only (b) elasticity only
(c) inertia as well as elasticity
(d) inertia, elasticity and external force.

7. The impurity atom with which pure germanium should be doped to make n-type semiconductor is not
(a) phosphorus (b) arsenic
(c) bismuth (d) boron.

8. The ionization energy of hydrogen atom is 13.6 eV. Following Bohr's theory, the energy corresponding to transition between third and fourth orbit will be
(a) 3.4 eV (b) 1.51 eV
(c) 0.85 eV (d) 0.66 eV.

9. Speeds of red light and yellow light are exactly same
(a) in vacuum but not in air
(b) in air but not in vacuum
(c) in vacuum as well as in air
(d) neither in vacuum nor in air.

10. A gun of weight 10 kg fires a shot of 0.5 g with a velocity 230 ms^{-1}. Velocity of recoil of the gun is

(a) $1.5\ \text{cms}^{-1}$ (b) $1.15\ \text{cms}^{-1}$
(c) $1.10\ \text{cms}^{-1}$ (d) $1.51\ \text{cms}^{-1}$.

11. On mountains roads are made spiral because they
(a) look beautiful
(b) save vehicles from turning over
(c) reduce speed
(d) have less steep slopes.

12. The displacement of a particle executing simple harmonic motion is given by $y = 1.2\sin(3.5t + 0.5x)$ where distances are in metre and t in second. The maximum velocity of the particle is
(a) $3.5\ \text{ms}^{-1}$ (b) $4.2\ \text{ms}^{-1}$
(c) $5.0\ \text{ms}^{-1}$ (d) none of these.

13. The equation of state of a gas can be expressed as $\left(P + \dfrac{a}{V^2}\right) = \dfrac{R\theta}{V}$. P = pressure, V = volume, θ = absolute temperature and a, R are constants. Dimensional formula of a is
(a) ML^5T^{-2} (b) $ML^{-5}T^2$
(c) $ML^{-1}T^{-2}$ (d) $M^{-1}L^5T^{-2}$.

14. A body starts from rest and moves with a uniform acceleration. The ratio of the distance covered in the n^{th} second to the distance covered in n second is
(a) $\dfrac{2}{n} - \dfrac{1}{n^2}$ (b) $\dfrac{2}{n^2} - \dfrac{1}{n}$
(c) $\dfrac{1}{n^2} - \dfrac{1}{n}$ (d) $\dfrac{2}{n} + \dfrac{1}{n^2}$

15. Three thin uniform rods of mass M and length L lie along the x, y, z-axes with one end of each at the origin. Moment of inertia I about the z-axis for the three-rod system is
(a) $\dfrac{ML^2}{12}$ (b) $\dfrac{ML^2}{3}$
(c) $\dfrac{2ML^2}{3}$ (d) ML^2.

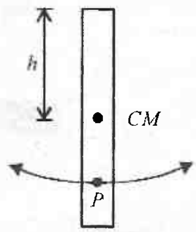
16. A satellite of mass m is revolving at a height h above the earth's surface. The radius of the earth is R and its mass is M. The orbital velocity for this satellite is given by
(a) $\sqrt{\dfrac{2GM}{R}}$ (b) $\sqrt{\dfrac{GM}{R+h}}$
(c) $\sqrt{\dfrac{2GM}{R+h}}$ (d) $\sqrt{\dfrac{GM}{2R}}$

17. Ratio of coefficient of thermal conductivity of two different materials is 4 : 3. To have same thermal resistance of the two rods of these materials of equal thickness, the ratio of their length should be
(a) 3/4 (b) 4/3
(c) 1/4 (d) 5/4.

18. Two bodies of masses M_A and M_B have equal kinetic energy. The ratio of their momenta is
(a) $M_A : M_B$ (b) $M_B : M_A$
(c) $\sqrt{M_A} : \sqrt{M_B}$ (d) $M_A^2 : M_B^2$.

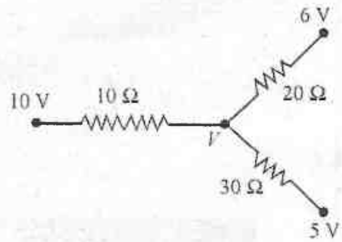
19. An object with mass m and speed v explodes into two pieces, one three times as massive as the other; the explosion takes place in a gravity free space. The less massive piece comes to rest. The change in kinetic energy of the system in the explosion is
(a) $\dfrac{1}{2}mv^2$ (b) $\dfrac{1}{4}mv^2$
(c) $\dfrac{1}{6}mv^2$ (d) $\dfrac{1}{3}mv^2$.

20. A meter stick, suspended from one end, swings as a physical pendulum. Its period of oscillation is given by



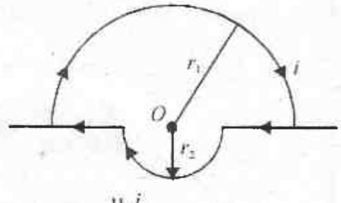
(a) 2 s
(b) 1.64 s
(c) 1.16 s
(d) 1 s.

21. Potential V in the given circuit is



(a) 9 V
(b) 32 V
(c) 8 V
(d) 5 V.

22. In figure there are two semicircles of radii r_1 and r_2 in which a current i is flowing. The magnetic induction at centre O will be



(a) $\dfrac{\mu_0 i}{4}(r_1 + r_2)$ (b) $\dfrac{\mu_0 i}{4}(r_1 - r_2)$
(c) $\dfrac{\mu_0 i}{4}\left(\dfrac{r_1 + r_2}{r_1 r_2}\right)$ (d) $\dfrac{\mu_0 i}{4}\left(\dfrac{r_1 - r_2}{r_1 r_2}\right)$

23. The dimensional formula of $e^2/\varepsilon_0 hc$ (where e, h, c are charge, Planck's constant and velocity of light), is that of

(a) work (b) impulse
(c) angle (d) stress.

24. The depth inside the earth at which the value of g is 50% of its value at the surface is

(a) R (b) $2R$ (c) $R/2$ (d) $R/4$.

25. If the momentum of a body varies with time according to the relation $P = t^3 - 6t^2 + 3$ Ns, then the time at which the maximum force acts on it, is

(a) 2 s (b) 6 s (c) 3 s (d) 4 s.

26. If the earth suddenly shrinks such that its radius becomes half of its present radius, then the duration of the day would become

(a) 6 hr (b) 18 hr (c) 12 hr (d) 96 hr.

27. The ratio of time taken by a disc and a sphere of equal radii, to reach the bottom of an inclined plane is given by

(a) $\sqrt{5/14}$ (b) 5/7
(c) $\sqrt{10/7}$ (d) $\sqrt{15/14}$

28. A simple pendulum oscillates with frequency n in air. On immersing in a liquid of density one sixth of the bob of the pendulum, it oscillates with the frequency

(a) $\frac{5}{6}n$ (b) $n\sqrt{\frac{5}{6}}$ (c) $\left(\frac{5}{6}\right)^2 n$ (d) n.

29. If a cube is put in a liquid of density 3 times the density of the material of the cube, then the fraction of the volume of the cube which remains inside the liquid is

(a) 1/4 (b) 1/2 (c) 2/3 (d) 1/3.

30. If the angular velocity of a body increases by 50%, then the percentage increase in the rotational kinetic energy is

(a) 225% (b) 125% (c) 25% (d) 50%.

31. A transformer changes 220 V to 22 V. If the currents in the primary and secondary coils are 10 A and 70 A respectively, then its efficiency will be

(a) 100% (b) 90% (c) 80% (d) 70%.

32. The power factor of LCR circuit at resonance is

(a) 0.707 (b) 1 (c) zero (d) 0.5

33. A person can not see objects clearly beyond 50 cm. The power of the lens to correct his vision will be

(a) + 2 D (b) – 2 D
(c) + 5 D (d) – 0.5 D.

34. The refractive index of the material of an equilateral prism is $\sqrt{2}$. The angle of minimum deviation produced by it will be

(a) 30° (b) 45°
(c) 60° (d) none of these.

35. The equations of light waves are $y_1 = 6\cos\omega t$, $y_2 = 8\cos(\omega t + \phi)$. These superpose to interfere. The ratio of maximum to minimum intensity in the interference pattern is

(a) 7 : 1 (b) 49 : 1
(c) 16 : 9 (d) none of these.

36. From Brewster's law it follows that the angle of polarisation depends upon

(a) wavelength of light
(b) orientation of plane of polarisation
(c) orientation of plane of vibration
(d) none of these.

37. At what temperature will the hydrogen molecules escape from earth's surface?

(a) 10^4 K (b) 10^3 K (c) 10^2 K (d) 10 K.

38. An iceberg (density 0.92 g/cc) is floating partly immersed in sea water (density 1.03 g/cc). The fraction of the total volume of the iceberg above the sea water, is

(a) 89% (b) 11% (c) 9.09% (d) 78%.

39. If M_i and M_g are the inertial and gravitational masses of a body respectively, then

(a) $M_g = 9.8\ M_i$ (b) $M_g = M_i$
(c) $M_g = M_i/9.8$ (d) $M_g = M_i/6$.

40. The gravitational field intensity is measured in

(a) $Nm^2\ kg^{-2}$ (b) $N\ kg^{-1}\ s^{-2}$
(c) N kg (d) $N\ kg^{-1}$.

Directions (Q. 41 to 60) : *In each of the following questions, a statement of assertion (A) is given and a corresponding statement of reason (R) is given just below it. Of the statements, mark the correct answer as*

(a) *if both A and R are true and R is the correct explanation of A*

(b) *if both A and R are true but R is not the correct explanation of A*
(c) *if A is true but R is false*
(d) *if both A and R are false.*

41. Assertion : The rainbow is seen sometimes in the sky when it is raining to an observer with his back towards the sun.
Reason : Total internal reflection from water droplets causes dispersion. The final rays are in the backward direction.

42. Assertion : The relative velocity of two photons travelling in opposite direction is C.
Reason : The rest mass of photon is zero.

43. Assertion : Brilliant colours are seen in thin layer of oil on the solution.
Reason : White light is composed of several colours.

44. Assertion : In LCR series circuit, the resonance occurs at one frequency only.
Reason : At resonance the inductive reactance is equal to the capacitive reactance.

45. Assertion : For a given mass of an ideal gas, at constant temperature the product of the pressure and volume is constant.
Reason : The mean square velocity of the molecules is inversely proportional to their masses at constant temperature.

46. Assertion : γ for a diatomic gas is more than for a monoatomic gas.
Reason : The molecules of a monoatomic gas have more degrees of freedom than those of a diatomic gas.

47. Assertion : Radiowaves can be polarised.
Reason : Sound waves are longitudinal waves.

48. Assertion : If a pendulum falls freely, then its time period becomes infinite.
Reason : Free falling body has acceleration equal to g.

49. Assertion : The couple acting on a body is not equal to the rotational kinetic energy of the body.
Reason : Couple and kinetic energy have different units.

50. Assertion : A thin aluminium disc spinning freely about a central pivot is quickly brought to rest when placed between the poles of a strong U-shaped magnet.
Reason : A current induced in a disc rotating in a magnetic field produces a force which tends to oppose the disc's motion.

51. Assertion : In a radioactive disintegration an electron is emitted by the nucleus.
Reason : Electrons are always present inside the nucleus.

52. Assertion : A dip needle becomes vertical at magnetic equator of the earth.
Reason : The magnetic field due to the earth at the magnetic equator is vertical.

53. Assertion : When two electrons are brought close to each other, the electrical potential energy increases.
Reason : Work must be done against electrical force of repulsion.

54. Assertion : If Young's double slit experiment is performed in water, the fringe width will decrease.
Reason : Wavelength of light in water is smaller than in air.

55. Assertion : Two satellites of masses m_1 and m_2 ($m_1 > m_2$) are going around the earth in orbits of radii r_1 and r_2 ($r_1 > r_2$).
Reason : They will have same velocity.

56. Assertion : It is not possible for a system, unaided by an external agency, to transfer heat from a body at lower temperature to another at higher temperature.
Reason : It is not possible to violate the second law of thermodynamics.

57. Assertion : In the absence of space charge, the potential gradient between cathode and the anode will be uniform.
Reason : The space charge reduces the potential in the cathode and anode region non-uniformly.

58. Assertion : A vibrating tuning fork sounds louder when its stem is put against a desk top.
Reason : When a wave reaches another denser medium, a part of the wave is reflected.

59. Assertion : Isotopes of an element can be separated by using a mass spectrometer.
Reason : Separation of isotopes is possible because of the difference in electron numbers of isotopes.

60. Assertion : A large soap bubble expands while a small bubble shrinks when they are connected to each other by a capillary tube.
Reason : The excess pressure inside bubble (or a drop) is inversely proportional to its radius.

The Editor, Physics For You, 406, Taj Apartment, Ring Road, Adjacent Safdarjung Hospital, New Delhi - 110 029.

Attach this form along with your response sheet. (Photocopy is not allowed). Please send a self addressed envelope along with postal stamps worth Rs.20. Do not fix the stamps on the envelope. The despatch will include ranking cum analysis sheet and solutions (detailed). Response sheet will not be entertained without the stamps. The last date of receipt of Response Sheets is 10th of next month.

Name ______________________ Board Passed/Appearing (Percentage & year)______________

Correspondence address ____

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No. of Questions Attempted .... **No. of Questions Unattempted** ....

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....

What you like most in Physics For You? ....

....

What suggestions would you like to give for its improvement? ....

....

Note : Solution sheet other than the one printed will not be accepted. Fill the correct answers in circles with blue/black ball point pen. **Sheet marked with pencils will not be accepted**. Don't tick (✓) mark.

ANSWER SHEET

1.	a	b	c	d	16.	a	b	c	d	31.	a	b	c	d	46.	a	b	c	d
2.	a	b	c	d	17.	a	b	c	d	32.	a	b	c	d	47.	a	b	c	d
3.	a	b	c	d	18.	a	b	c	d	33.	a	b	c	d	48.	a	b	c	d
4.	a	b	c	d	19.	a	b	c	d	34.	a	b	c	d	49	a	b	c	d
5.	a	b	c	d	20.	a	b	c	d	35.	a	b	c	d	50.	a	b	c	d
6.	a	b	c	d	21.	a	b	c	d	36.	a	b	c	d	51.	a	b	c	d
7.	a	b	c	d	22.	a	b	c	d	37.	a	b	c	d	52.	a	b	c	d
8.	a	b	c	d	23.	a	b	c	d	38.	a	b	c	d	53.	a	b	c	d
9.	a	b	c	d	24.	a	b	c	d	39.	a	b	c	d	54.	a	b	c	d
10.	a	b	c	d	25.	a	b	c	d	40.	a	b	c	d	55.	a	b	c	d
11.	a	b	c	d	26.	a	b	c	d	41.	a	b	c	d	56.	a	b	c	d
12.	a	b	c	d	27.	a	b	c	d	42.	a	b	c	d	57.	a	b	c	d
13.	a	b	c	d	28.	a	b	c	d	43.	a	b	c	d	58.	a	b	c	d
14.	a	b	c	d	29.	a	b	c	d	44.	a	b	c	d	59.	a	b	c	d
15.	a	b	c	d	30.	a	b	c	d	45.	a	b	c	d	60.	a	b	c	d

Practice Paper *for* West Bengal JEE 2006

Exam on 22^{nd} and 23^{rd} April 2006

1. A particle of mass 10 gram is executing simple harmonic motion with an amplitude of 0.5 m and circular frequency of 10 radian/sec. The maximum value of the force acting on the particle during the course of the oscillation is
(a) 25 newton (b) 2.5 newton
(c) 5 newton (d) 0.5 newton

2. A copper wire and a steel wire of same diameter and length are connected end to end and a force is applied which stretches their combined length by 1 cm. The two wires will have
(a) same stress and strain
(b) different stress and strain
(c) different stress and same strain
(d) same stress and different strain.

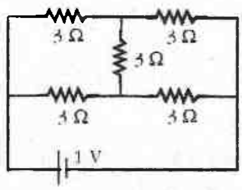
3. A force of 5 N acts on a body of 5 kg for 1 second and gives it a momentum p and kinetic energy E. If the same force accelerates the same body through 1 m, the momentum and energy attained by the body are p' and E' respectively.
Which of the following relation is correct?
(a) $p > p', E > E'$ (b) $p < p', E < E'$
(c) $p > p', E < E'$ (d) $p < p', E > E'$.

4. Roadways are banked on curves so that
(a) the weight of the vehicle may be decreased.
(b) the frictional force between the road and vehicle may be decreased
(c) the wear and tear of tyres may be avoided
(d) the speeding vehicles may not fall inwards.

5. An object is placed at a distance of 30 cm from a concave mirror and its real image is formed at a distance of 30 cm from the mirror. The focal length of the mirror is
(a) 15 cm (b) 45 cm
(c) 30 cm (d) 20 cm

6. A motor cyclist moving with a velocity of 72 km/h on a flat road takes a turn on the road at a point where radius of curvature of road is 20 m. In order to avoid skidding, he must not bend with respect to the vertical plane by an angle θ greater than
(a) $\tan^{-1}(6)$ (b) $\tan^{-1}(2)$
(c) $\tan^{-1}(25.92)$ (d) $\tan^{-1}(4)$.

7. In the given figure, the current in the cell is

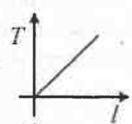


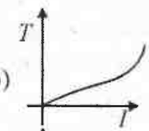
(a) 33 A
(b) 3.3 A
(c) 0.33 A
(d) 3.32 A.

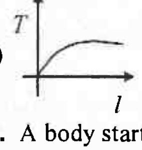
8. The critical angle of light passing from glass to air is minimum for
(a) red (b) green
(c) yellow (d) violet.

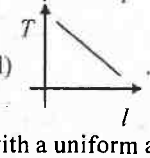
9. Ten identical electric bulbs, each rated 220 V, 50 W are used in parallel on 200 V line for 10 hours a day in month of 30 days. The electric energy consumed in kWh is
(a) 5 kWh (b) 50 kWh
(c) 15 kWh (d) 1500 kWh.

10. Variation of time period of a simple pendulum with its length is as in

(a) 

(b) 

(c) 

(d) 

11. A body start from rest with a uniform acceleration of 2 m/s^2 for 10 sec. it move with constant speed for 30 sec then deaccelerated by 4 m/s^2 to zero. What is the distance covered by the body?
(a) 750 m (b) 850 m
(c) 600 m (d) none of these.

12. A solenoid is taken and an iron rod is inserted into it then which of the following quantities will not change
(a) magnetic field at the centre
(b) magnetic flux linked with the solenoid
(c) self inductance of the solenoid
(d) joule heating.

13. Two mirrors are placed at right angles to each other. A man is standing between them combing his hair. How many images he will see?
(a) 3 (b) 2
(c) 1 (d) 0.

14. A sine wave has an amplitude A and wavelength λ. Let V be the wave velocity and v be the maximum velocity of a particle in the medium. Then
(a) $V = v$ if $\lambda = \frac{3A}{2\pi}$ (b) $V = v$ if $A = 2\pi\lambda$
(c) $V = v$ if $A = \frac{\lambda}{2\pi}$ (d) V can not be equal to v.

15. A body starts from rest with uniform acceleration. The velocity of the body after t sec. is v. The displacement of the body in last 3 sec. is
(a) $3v\left(1 - \frac{3}{2t}\right)$ (b) $\frac{3v}{2}(t-3)$
(c) $\frac{3v}{2}(t+3)$ (d) none of these.

16. A body of mass 0.10 kg is being rotated in a circular path of diameter 1.0 m on a frictionless horizontal plane by means of a string. It performs 10 revolutions in 31.4 sec. The centripetal force acting on the body is
(a) 2 N (b) 2.4 N
(c) 0.2 N (d) 0.5 N.

17. If the coefficient of apparent expansion of a liquid in a copper vessel is C and in a silver vessel is S and the co-efficient of linear expansion of copper is A, then the co-efficient of linear expansion of silver is
(a) $\frac{(C+S-3A)}{3}$ (b) $\frac{(S+3A-C)}{3}$
(c) $\frac{(C+3A-S)}{3}$ (d) $\frac{(C+S+3A)}{3}$.

18. A current I ampere flows in a circular wire of radius r subtending an angle $\pi/2$ radian at the centre. The magnetic induction B at the centre will be
(a) $\frac{\mu_0 I}{r}$ (b) $\frac{\mu_0 I}{2r}$
(c) $\frac{\mu_0 I}{4r}$ (d) $\frac{\mu_0 I}{8r}$.

19. An immersion heater of 1 kW will take the time for increasing the temperature of 1 litre of water through 10°C equal to
(a) 10 s (b) 24 s
(c) 42 s (d) 100 s.

20. A galvanometer is shunted by $1/n^{th}$ of its resistance. The fraction of the current passing through the galvanometer is
(a) $\frac{I}{n-1}$ (b) $\frac{I}{n+1}$
(c) $\frac{I_g}{n+1}$ (d) $\frac{I_g}{n-1}$.

21. The peak value of voltage in 220 volt a.c. mains is
(a) 155.6 volt (b) 220 volt
(c) 311 volt (d) 440 volt.

22. If $\vec{A} = 4\hat{i} + 4\hat{j} - 4\hat{k}$ and $\vec{B} = 3\hat{i} + \hat{j} + 4\hat{k}$, the angle between the vectors is
(a) 0° (b) 45°
(c) 60° (d) 90°.

23. Two waves having a phase difference of 60° will have a path difference of
(a) $\lambda/2$ (b) $\lambda/3$
(c) $\lambda/6$ (d) 2λ.

24. To obtain 3 μF capacity from three capacitors of 2 μF each, they will be arranged
(a) all the three in series
(b) all the three in parallel
(c) two capacitors in series and the third in parallel with the combination of the two
(d) two capacitors in parallel and the third in series with the combination of the two.

25. A magnet of magnetic moment M is freely suspended in a uniform magnetic field of strength B. The work done in rotating the magnet through an angle θ is given by
(a) BM (b) $MB\sin\theta$
(c) $MB\cos\theta$ (d) $MB(1 - \cos\theta)$.

26. An automobile engine develops 100 kW when rotating at a speed of 1800 rev/min. What torque does it deliver?
(a) 350 N-m (b) 440 N-m
(c) 531 N-m (d) 628 N-m.

27. At what height from the earth surface, the acceleration of gravity will be half the value of g at surface.

(R = 6400 km)

(a) 2650 km (b) 3200 km
(c) 4800 km (d) 6400 km.

28. Two waves are approaching each other with a velocity of 20 m/s and frequency n. The distance between two consecutive nodes is

(a) $20/n$ (b) $10/n$
(c) $5/n$ (d) $n/10$.

29. Coefficient of superficial expansion of a solid is 2×10^{-5}/°C. Its coefficient of linear expansion is

(a) 1×10^{-5}/°C (b) 2×10^{-5} /°C
(c) 3×10^{-5} /°C (d) 4×10^{-5} /°C.

30. If the capacitance of a spherical conductor is 1 μF, then its diameter would be

(a) 1.8×10^3 m (b) 18×10^3 m
(c) 1.8×10^7 m (d) 18×10^7 m.

31. A wire has a resistance of 3.1 Ω at 30°C and a resistance 4.5 Ω at 100°C. The temperature coefficient of resistance of the wire is

(a) 0.0064 °C^{-1} (b) 0.0034 °C^{-1}
(c) 0.0025 °C^{-1} (d) 0.0012 °C^{-1}.

32. The internal resistance of a cell is the resistance of

(a) electrodes of the cell (b) vessel of the cell
(c) electrolyte used in the cell
(d) material used in the cell.

33. An astronomical telescope has a length of 44 cm and tenfold magnification. The focal length of the objective lens is

(a) 4 cm (b) 40 cm
(c) 44 cm (d) 440 cm.

34. If a spring extends by x on loading, then energy stored by the spring is (if T is the tension in the spring and k is the spring constant)

(a) $T^2/2x$ (b) $T^2/2k$
(c) $2k/T^2$ (d) $2T^2/k$.

35. A copper ring is moved quickly towards the south pole of a powerful stationary bar magnet. As a result

(a) copper ring will get attracted
(b) copper ring will get magnetised
(c) a current flows in the magnet
(d) current flows through copper ring.

36. A small piece of metal wire is dragged across the gap between the poles pieces of a magnet in 0.4 sec. If magnetic flux between the pole pieces is known to be 8×10^{-4} Wb, then induced emf in the wire is

(a) 8×10^{-3} V (b) 6×10^{-3} V
(c) 4×10^{-3} V (d) 2×10^{-3} V.

37. A closely wound flat circular coil of 25 turns of wire has diameter of 10 cm and carries a current of 4 ampere. Determine the flux density at the centre of a coil.

(a) 1.679×10^{-5} tesla (b) 2.028×10^{-4} tesla
(c) 1.257×10^{-3} tesla (d) 1.512×10^{-6} tesla.

38. The magnitude of acceleration of the car is maximum

(a) on applying brakes
(b) on pressing the accelerator
(c) on starting the car (d) on turning off the car.

39. The extraction of cream from milk when it is chumed depends upon

(a) centrifugal force (b) centripetal force
(c) cohesive force (d) gravitational force.

40. The coefficient of restitution depends upon

(a) the masses of the colliding bodies
(b) the direction of motion of the colliding bodies
(c) the inclination between the colliding bodies
(d) the materials of the colliding bodies.

41. The coefficient of thermal conductivity of a rod depends on

(a) nature of material of rod
(b) volume of rod (d) temperature of rod
(d) area of cross-section of the rod.

42. Photoelectric threshold wavelength for tungsten is 2300 Å. Work function will be

(a) 5.39 eV (b) 53.9 eV
(c) 5.39×10^{-3} eV (d) none of these.

43. An electron is accelerated at 10 kV to a tungsten target. The wavelength of the X-ray photon produced will be

(a) 0.62 Å (b) 2.48 Å
(c) 0.124 mm (d) 1.24 Å.

44. A rectangular coil of area 20 cm × 15 cm and of turns 485 is revolving in a uniform magnetic field of intensity 20 Wb/m^2 with a speed of 1800 rpm. Find the emf developed in the coil when it makes an angle of 60° with the field?

(a) 45.7×10^4 V (b) 74.5×10^4 V
(c) 4.75×10^4 V (d) 7.45×10^4 V.

45. A horizontal wire 0.1 m long carries a current of 5 A. Find the magnitude and direction of an independent magnetic field which can support the weight of the wire, assuming its mass to be 3×10^{-3} kg m^{-1}?
(a) 58.8×10^{-3} T, horizontal
(b) 5.88×10^{-3} T, horizontal
(c) 88.5×10^{-3} T, down vertical
(d) 85.8×10^{-3} T, vertical.

46. If the ratio of maximum and minimum intensities in an interference pattern is 36 : 1, the ratio of the amplitudes of the two interfering waves will be
(a) 5 : 7 (b) 7 : 4 (c) 4 : 7 (d) 7 : 5.

47. The equatuion, $y = 0.15\sin 5x \cos 300t$ represents a stationary wave. The wavelength of this stationary wave will be
(a) zero (b) 1.256 m
(c) 2.512 m (d) 0.628 m

48. Two rods of same material have diameters in the ratio 1 : 2 and lengths in the ratio 2 : 1. If the temperature difference between their ends is the same, the ratio of heats conducted by them in a given time will be
(a) 8 : 1 (b) 1 : 8 (c) 4 : 1 (d) 1 : 4.

49. A surface encloses in an electric dipole. The flux through the surface is
(a) zero (b) positive
(c) negative (d) infinite.

50. When using a triode as an amplifier, the electrons are emitted by
(a) anode and collected by cathode only
(b) anode and collected by the grid and by cathode
(c) grid and collected by cathode only
(d) cathode and collected by anode only.

51. Calculate the velocity of sound in air at 20°C, when the atmospheric pressure is 76 cm of mercury. Given that $\gamma = 1.41$ and density of air is 0.001293 gm per cc. at 0°C.
(a) 344.7 m/s (b) 375.4 m/s
(c) 320 m/s (d) 365.3 m/s.

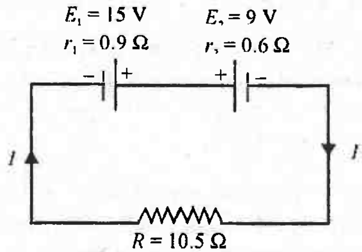
52. Most room heaters rely on
(a) conduction (b) radiation
(c) convection (d) all of these.

53. Electrical fuses are usually made of
(a) copper (b) aluminium
(c) manganin (d) wood's metal.

54. Calculate the capacitance of a parallel plate capacitor, the potential plate of which has an area 200 cm^2. The distance between the plates is 1 cm and it is filled up by an abonite plate of S.I.C. = 3.
(a) 77.4 e.s.u. (b) 47.7 e.s.u
(c) 4.77 e.s.u (d) 477.0 e.s.u.

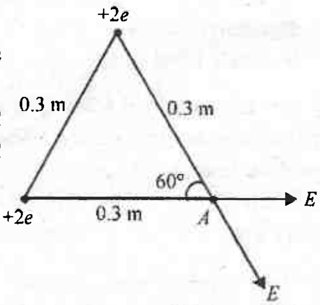
55. A wire, having 1 mm^2 cross-sectional are carries a current of 3.2 ampere. If the drift velocity of the electrons be 2 cms^{-1}, find the number of electrons per unit volume of the wire. Charge of an elect.on = 1.6×10^{-19} coulomb.
(a) 10^{18} (b) 10^{72} (c) 10^{27} (d) 10^{30}.

56. Two batteries of e.m.f. 15 volt and 9 volt and internal resistances 0.9 ohm and 0.6 ohm respectively, are connected with 10.5 ohm as shown in the figure. Calculate the current in the circuit?



(a) 0.5 A (b) 5.0 A
(c) 0.05 A (d) 0.005 A.

57. Find the electric intensity at A.
(a) 0.3464×10^{11} N/C
(b) 346.64×10^{11} N/C
(c) 34.64×10^{11} N/C
(d) 3.464×10^{11} N/C.



58. Of the following quantities, which one has dimensions different from the others?
(a) pressure (b) torque
(c) stress (d) modulus of elasticity.

59. If P and Q are two vectors, then the correct relation is
(a) $\vec{P} + \vec{Q} = \vec{Q} - \vec{P}$ (b) $\vec{P} + \vec{Q} = \vec{Q} + \vec{P}$
(c) $\vec{P} \times \vec{Q} = \vec{Q} \times \vec{P}$ (d) $\vec{P} \times \vec{Q} - \vec{P} \cdot \vec{Q}$.

60. Magnifying power of a telescope is M. If the focal length of its eye-piece is doubled, then the magnifying power is
(a) $2M$ (b) M (c) $3M$ (d) $M/2$.

61. Which of the following statements is not correct in respect to a body in uniform circular motion?
(a) its kinetic energy is constant
(b) its acceleration is constant
(c) its speed is constant
(d) its angular velocity is constant.

62. When monochromatic light travels from air to another medium, say glass
(a) frequency decreases (b) frequency increases
(c) wavelength decreases (d) wavelength increases.

63. A ball collides elastically with another ball of the same mass. The collision is oblique and initially one of the balls was at rest. After the collision the two balls move with same speed. What will be the angle between the velocities of the balls after the collision?
(a) 30° (b) 45° (c) 60° (d) 90°.

64. The orbital speed of a satellite in a circular orbit of radius r about a spherical planet of mass M and mean density ρ for a low altitude orbit ($r = r_p$) will be
(a) $\sqrt{\frac{3\pi}{G\rho}}$ (b) $\sqrt{3\pi G\rho}$
(c) $\sqrt{\pi / G\rho}$ (d) $\sqrt{2G\rho}$.

65. Density of ice is ρ and that of water is σ. What will be the decrease in volume when a mass M of ice melts?
(a) $\frac{M}{(\sigma-\rho)}$ (b) $\frac{\sigma-\rho}{M}$
(c) $M\left[\frac{1}{\rho}-\frac{1}{\sigma}\right]$ (d) $\frac{1}{M}\left[\frac{1}{\rho}-\frac{1}{\sigma}\right]$.

66. A point source emits sound equally in all directions in a non-absorbing medium. Two points P and Q are at a distance 9 metre and 25 metre respectively from the source. The ratio of the amplitudes of the waves at P and Q is
(a) 25/9 (b) 9/25 (c) 5/3 (d) 3/5.

67. Two concentric spheres of radii R and r have similar charges with equal surface densities (σ). What is the electric potential at their common centre?
(a) $\frac{\sigma}{\varepsilon_0}$ (b) $\frac{\sigma}{\varepsilon_0}(R-r)$
(c) $\frac{\sigma}{\varepsilon_0}(R+r)$ (d) none of these.

68. A particle carrying a charge equal to 100 times the charge on an electron is rotating once per second in a circular path of radius 0.8 m. The value of the magnetic field produced at the centre will be (μ_0 = permeability constant)
(a) $10^{-7}/\mu_0$ (b) $10^{-17}\,\mu_0$
(c) $10^{-6}/\mu_0$ (d) $10^{-7}\,\mu_0$.

69. The magnetic moment of a short magnet is 8 amp. m^2. What is the magnetic induction at a point 20 cm away on its equatorial line from its mid point?
(a) 10^{-4} weber/m^2 (b) 2×10^{-4} weber/m^2
(c) 3×10^{-4} weber/m^2 (d) 4×10^{-4} weber/m^2.

70. A group of electric lamps having a total power rating of 1000 watt is supplied by an A.C. voltage $E = 200 \sin(310t + 60°)$. Then the rms value of the circuit current is
(a) 10 amp (b) $10\sqrt{2}$ amp
(c) 20 amp (d) $20\sqrt{2}$ amp

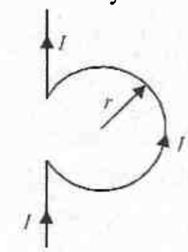
71. Time taken by the sunlight to pass through a window of thickness 4 mm whose refractive index is 1.5 is
(a) 2×10^{-8} second (b) 2×10^{8} second
(c) 2×10^{-11} second (d) 2×10^{11} second.

72. Angle of deviation (δ) by a prism (refractive index = μ and supposing the angle of prism A to be small) can be given by
(a) $\delta = (\mu - 1)A$ (b) $\delta = (\mu + 1)A$
(c) $\delta = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin(A/2)}$ (d) $\delta = \frac{(\mu-1)}{(\mu+1)}$

73. The amplification factor of a triode is 20. Its plate resistance is 10 kilo-ohm. Its mutual conductance will be
(a) 2×10^{5} mho (b) 2×10^{4} mho
(c) 500 mho (d) 2×10^{-3} mho.

74. On increasing the reverse bias to a large value in a P-N junction diode, the current
(a) increases slowly (b) remains constant
(c) suddenly increases (d) decreases slowly.

75. A long straight conductor, carrying a current I, is bent to form an almost complete circular loop of radius r. The magnetic field at the centre of the loop has magnitude



(a) $\frac{\mu_0}{2}\left(1-\frac{1}{\pi}\right)$

(b) $\frac{\mu_0 I}{r}(1+\pi)$ (c) $\frac{\mu_0 I}{2r}\left(1-\frac{1}{\pi}\right)$

(d) $\frac{\mu_0 I}{2r}\left(1+\frac{1}{\pi}\right)$

76. Which of the following statements is correct?

(a) A charged particle can be accelerated by a magnetic field.

(b) A charged particle can not be accelerated by a magnetic field.

(c) The speed of a charged particle can be increased by a uniform magnetic field.

(d) The speed of a charged particle can be increased by a non-uniform magnetic field.

77. Suppose the earth stops rotating about its axis. Then the value g at the equator would :

(a) become zero (b) remain unchanged

(c) increase by $\omega^2 R$ (d) decrease by $\omega^2 R$

78. A thin prism P of angle 4° and made of glass of refractive index 1.54 is combined with another thin prism P' of refractive index 1.72 for dispersion without deviation. The angle of prism of P' will be

(a) 2.6° (b) 4° (c) 5.33° (d) 3°.

79. If the velocity of sound in hydrogen is 1500 m, then its velocity in a mixture of three parts of oxygen and two parts of hydrogen by volume will be

(a) 385.7 m/s (b) 474.4 m/s

(c) 536.3 m/s (d) 676.9 m/s.

80. 56 tuning forks are arranged such that each fork produces 4 beats per second with its preceding fork. The frequency of the last fork is three times that of first. The frequency of the first fork will be

(a) 220 Hz (b) 110 Hz (c) 330 Hz (d) 440 Hz.

81. A metal wire of length L, area of cross-section A and Youngs modulus Y behaves as a spring of spring constant

(a) $k=\frac{YA}{L}$ (b) $k=\frac{2YA}{L}$

(c) $k=\frac{YA}{2L}$ (d) $k=\frac{YL}{A}$.

82. If $y=x-\frac{1}{2}x^2$ is the equation of a trajectory, find the time of flight.

(a) $\frac{2}{\sqrt{g}}$ (b) $\frac{\sqrt{2}}{g}$ (c) $\frac{2}{g}$ (d) $\frac{1}{2g}$.

83. Two springs A and B are alike and W is the work done in stretching the spring. A is stiffer than B ($k_A > k_B$). If they are elongated through the same distance, then

(a) $W_A > W_B$ (b) $W_A < W_B$

(c) $W_A = W_B$ (d) none of these.

84. A solid sphere rolls on an inclined plane with an acceleration of 3.5 m/s^2. The angle made by the incline with the horizontal is

(a) 30° (b) 45° (c) 60° (d) 75°.

85. What will be the number of molecules in 10^{-6} m^3 air at 10^5 N/m^2 pressure and 300 K temeperature? (Boltzmann's constant = 1.38×10^{-23} JK^{-1})

(a) 32.0×10^{15} (b) 3.2×10^{-23}

(c) 2.3×10^{91} (d) 2.3×10^{19}.

86. A red hot body emits

(a) thermal radiations (b) ultraviolet rays

(c) thermal radiation alongwith red light

(d) all of these.

87. The dispersive power of a prism depends on

(a) angle of the prism (b) material of the prism

(c) angle of the prism and material of the prism both

(d) none of the angle of prism and material of prism.

88. Line spectrum is obtained from

(a) yellow light of candle

(b) light of electric bulb

(c) Bunsen burner (d) sodium lamp.

89. 64 water drops alike in all respects have been charged to the same potential. Their total electrostatic energy is E. All these drops combine to form one big drop. The energy of the big drop will be

(a) $8E$ (b) $16E$ (c) $32E$ (d) $4E$.

90. Kilowatt hour is the unit of

(a) energy (b) power

(c) electric charge (d) electric current.

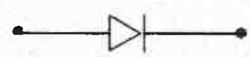
91. Two separate straight conductors carry parallel currents in opposite directions. They will

(a) attract each other (b) repel each other

(c) neither attract nor repel each other

(d) try to be perpendicular to each other.

92. Identify the following sketch.



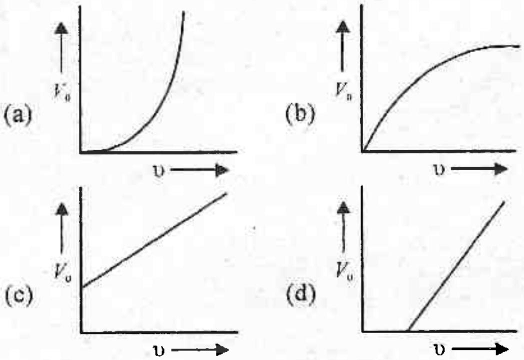
(a) P-N-P transistor

(b) N-P-N transistor

(c) PN junction diode (d) photocell.

93. For a ring, disc, solid sphere and spherical shell of same mass and radius the moment of inertia about an axis passing through their centre will respectively be maximum and minimum in case of
(a) ring and disc (b) ring and spherical shell
(c) ring and solid sphere
(d) solid sphere and spherical shell.

94. For a photoelectric cell, the graph showing the variation of cut-voltage (V_0) with frequency (υ) of incident radiation is



95. A uniform electric field E is directed along $+x$-axis. If the potential V is 0 at $x = 0$, then the potential at a point $+x$ will be
(a) $-xE$ (b) xE (c) x^2E (d) $-x^2E$.

96. A 500 μF capacitor is charged at a steady state of 100 μC per second. A potential difference of 10 volt will be developed between the capacitor plates after
(a) 5 sec (b) 10 sec (c) 20 sec (d) 50 sec.

97. Pick out the incorrect statement.
(a) 1 volt × 1 coulomb = 1 joule
(b) 1 volt × 1 ampere = 1 joule/sec
(c) 1 volt × 1 watt = 1 horse-power
(d) watt-hour can be expressed in electron volt.

98. The SI unit of magnetic field is tesla (T). It may also be written as
(a) $JA^{-2}\ m^{-2}$ (b) $JA^{-1}\ m^{-1}$
(c) $JA^{-1}\ m^{-2}$ (d) $JA^{-1}\ m^{-3}$.

99. The correct sequence of diamagnetic, paramagnetic and ferromagnetic substances respectively is
(a) liquid oxygen, magnetite, water
(b) water, liquid oxygen, magnetite
(c) liquid oxygen, water, magnetite
(d) none of these.

100. When a glass rod rubbed with silk is brought near the gold leaf electroscope, the leaves diverge. The charge on the leaves is
(a) positive
(b) negative
(c) either positive or negative
(d) equal and opposite.

ANSWERS

1. (d)	2. (d)	3. (b)	4. (d)	5. (a)
6. (b)	7. (c)	8. (d)	9. (c)	10. (c)
11. (a)	12. (d)	13. (a)	14. (c)	15. (a)
16. (c)	17. (c)	18. (d)	19. (c)	20. (b)
21. (c)	22. (d)	23. (c)	24. (c)	25. (d)
26. (c)	27. (a)	28. (b)	29. (a)	30. (b)
31. (a)	32. (c)	33. (b)	34. (b)	35. (d)
36. (d)	37. (c)	38. (a)	39. (a)	40. (d)
41. (a)	42. (a)	43. (d)	44. (c)	45. (b)
46. (d)	47. (b)	48. (b)	49. (a)	50. (d)
51. (a)	52. (c)	53. (d)	54. (b)	55. (c)
56. (a)	57. (d)	58. (b)	59. (b)	60. (d)
61. (b)	62. (c)	63. (d)	64. (a)	65. (c)
66. (a)	67. (c)	68. (b)	69. (a)	70. (b)
71. (c)	72. (a)	73. (d)	74. (c)	75. (c)
76. (a)	77. (c)	78. (d)	79. (b)	80. (b)
81. (a)	82. (a)	83. (a)	84. (a)	85. (d)
86. (c)	87. (b)	88. (d)	89. (b)	90. (a)
91. (b)	92. (c)	93. (c)	94. (d)	95. (a)
96. (d)	97. (d)	98. (c)	99. (b)	100. (a)

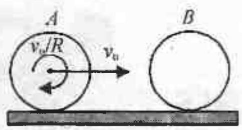
SAMPLE PAPER FOR IIT-JEE 2006

Based on *New pattern*

(For Q.No. 1 to 60) Only one option is correct and there will be negative marking in these questions.

1. There is a small hole in the bottom of a fixed container containing a liquid upto a height h. The top of the liquid as well as the hole at the bottom are exposed to atmosphere. As the liquid comes out of the hole, (area of the hole is a and that of the top surface is A)
(a) the top surface of the liquid accelerates with acceleration $= g$
(b) the top surface of the liquid accelerates with acceleration $= g\frac{a^2}{A^2}$
(c) the top surface of the liquid retards with retardation $= g\frac{a}{A}$
(d) the top surface of the liquid retards with retardation $= \frac{ga^2}{A^2}$.

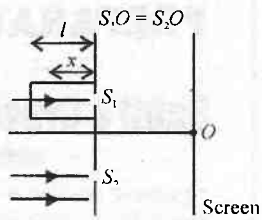
2. A hollow smooth uniform sphere A of mass m rolls without sliding on a smooth horizontal surface. It collides elastically and head on with another stationary smooth solid sphere B of the same mass m and same radius. The ratio of kinetic energy of B to that of A just after the collision is



(a) 5 : 2 (b) 1 : 1 (c) 2 : 3 (d) 3 : 2.

3. A string of length l is fixed at both ends. It is vibrating in its 3[rd] overtone with maximum amplitude a. The amplitude at a distance $l/3$ from one end is
(a) a (b) 0
(c) $\frac{\sqrt{3}a}{2}$ (d) $a/2$.

4. In the figure shown, a parallel beam of light is incident on the plane of the slits of a Young's double slit experiment. Light incident on the slit, S_1 passes through a medium of variable refractive index $\mu = 1 + ax$ (where x is the distance from the plane of slits as shown), upto a distance l before falling on S_1. Rest of the space is filled with air. If at O a minima is formed, then the minimum value of the positive constant a (in terms of l and wavelength λ in air) is

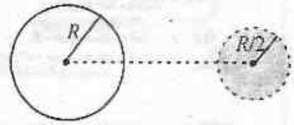


(a) λ/l (b) λ/l^2
(c) l^2/λ (d) none of these.

5. Three infinitely long line charges are arranged along the three co-ordinate axes. The magnitude of electric field at a point P (a, a, a) is [λ = charge per unit length on each line charge, $k = 1/4\pi\varepsilon_0$]
(a) $\frac{2k\lambda}{a}$ (b) $\frac{\sqrt{6}k\lambda}{a}$ (c) $\frac{6k\lambda}{a}$ (d) $\frac{2\sqrt{3}k\lambda}{a}$

6. A bob is attached to a long, light string. The string is deflected by 30° initially with respect to vertical. The length of the string is 1 m. The value of θ at any time t after the bob has been released is (Use $g = \pi^2$)
(a) $30°\cos\pi t$ (b) $30°\sin\pi t$
(c) $30°\sin(\pi t + 30°)$ (d) none of these.

7. A ring of radius R having a linear charge density λ moves towards a solid imaginary sphere of radius $R/2$, so that the centre of ring passes through the centre of sphere. The axis of the ring is perpendicular to the line joining the centres of the ring and the sphere. The maximum flux through the sphere in this process is



(a) $\frac{\lambda R}{\varepsilon_0}$ (b) $\frac{\lambda R}{2\varepsilon_0}$ (c) $\frac{\lambda\pi R}{4\varepsilon_0}$ (d) $\frac{\lambda\pi R}{3\varepsilon_0}$

8. Two particles P and Q describe simple harmonic

Contributed by Deptt. of Physics, **Resonance**, Kota (Rajasthan)

motions of same period, same amplitude along the same line about the same equilibrium position O. When P and Q are on opposite sides of O at the same distance from O they have the same speed of 1.2 m/s in the same direction, when their displacements are same they have the same speed of 1.6 m/s in opposite directions. The maximum velocity in m/s of either particle is

(a) 3 (b) 2.5 (c) 2.4 (d) 2.

9. If we assume that penetrating power of any radiation/particle is inversely proportional to wavelength of the particle then

(a) a proton and an α-particle after getting accelerated through same potential difference will have equal penetrating power

(b) penetrating power of α-particle will be greater than that of proton which have been accelerated by same potential difference

(c) proton's penetrating power will be less than penetrating power of an electron which has been accelerated by the same potential difference

(d) penetrating powers can not be compared as all these are particles having no wavelength or wave nature.

10. A hydrogen atom is in the 4^{th} excited state, then

(a) the maximum number of possible transitions will be 10

(b) the maximum number of possible transitions will be 6

(c) it can emit three photons in ultraviolet region

(d) if an infrared photon is generated, then a visible photon may follow this infrared photon.

11. A free standing wall of height h and thickness t and density ρ_w rests on a rough floor. A wind of speed v and density ρ_a blows against the wall. Assuming air is stopped when it reaches the wall and there is sufficient friction on the ground so that the wall does not slide, the minimum velocity v so that the wall topples is

(a) $\left(\dfrac{\rho_w g}{\rho_a h}\right)^{1/2} t$ (b) $\left(\dfrac{\rho_a g}{\rho_w h}\right)^{1/2} t$

(c) $\left(\dfrac{g}{h}\right)^{1/2} t$ (d) none of these.

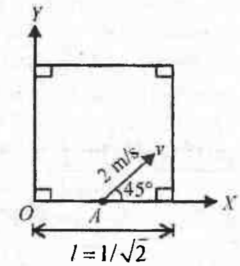
12. Minimum value of coefficient of friction, in the above question so that the wall only topples and does not slide for a given velocity v is

(a) $\dfrac{1}{2}\dfrac{\rho_a v^2}{\rho_w g t}$ (b) $\dfrac{\rho_a v^2}{\rho_w g t}$ (c) $\dfrac{v^2}{gt}$ (d) none.

13. Total friction force acting on the wall in the above question is (take length of wall to be l)

(a) $\rho_a l t v^2$ (b) $\rho_a l h v^2$ (c) $\rho_w l h v^2$ (d) $\rho_w l t v^2$.

14. A striker is shot from a square carrom board from a point A exactly at midpoint of one of the walls with a speed 2 m/sec at an angle of 45° with the x-axis as shown. The collisions of the striker with the walls of the fixed carrom are perfectly elastic. The coefficient of kinetic friction between the striker and board is 0.2. The coordinate of the striker when it stops (taking point O to be the origin) is



(a) $\dfrac{1}{2\sqrt{2}}, \dfrac{1}{\sqrt{2}}$ (b) $0, \dfrac{1}{2\sqrt{2}}$

(c) $\dfrac{1}{2\sqrt{2}}, 0$ (d) $\dfrac{1}{\sqrt{2}}, \dfrac{1}{2\sqrt{2}}$.

15. Consider a spherical planet rotating about its axis. The velocity of a point on its equator is v. The angular velocity of this planet is such that it makes apparent value of g at the equator half of value of g at the pole. The escape velocity for a polar particle on the planet expressed as a multiple of v is

(a) v (b) $2v$

(c) $3v$ (d) data insufficient.

16. The angular momentum of a particle about origin is varying as $L = 4t + 8$ (S.I. units) when it moves along a straight line $y = x - 4$ (x, y in meters). The force acting on the particle would be

(a) 1 N (b) 2 N (c) $\sqrt{2}$ N (d) $\sqrt{3}$ N.

17. The elongation in a metallic rod hinged at one end and rotating in a horizontal plane becomes four times of the initial value. The angular velocity of rotation becomes

(a) two times the initial value

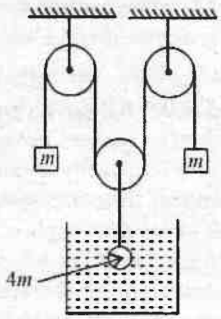
(b) half of initial value (c) one third of initial value

(d) four times the initial value.

18. Number of identical photons incident on a perfectly black body of mass m kept at rest on smooth horizontal surface. Then the acceleration of the body if n number of photons incident per sec is (Assume wavelength of photon to be λ)

(a) $\dfrac{nh}{2\pi\lambda m}$ (b) $\dfrac{nh}{\lambda m}$ (c) $\dfrac{2\pi nh}{\lambda m}$ (d) $\dfrac{\lambda m}{nh}$

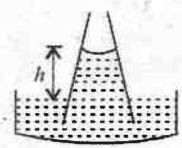
19. A spherical ball of mass $4m$, density σ and radius r is attached to a pulley-mass system as shown in figure. The ball is released in a liquid of coefficient of viscosity η and density ρ ($< \sigma/2$). If the length of the liquid column is sufficiently long, the terminal velocity attained by the ball is given by (assume all pulleys to be massless and string as massless and inextensible)



(a) $\frac{1}{9}\frac{r^2(2\sigma-\rho)g}{\eta}$ (b) $\frac{1}{9}\frac{r^2(\sigma-2\rho)g}{\eta}$

(c) $\frac{1}{9}\frac{r^2(\sigma-4\rho)g}{\eta}$ (d) $\frac{1}{9}\frac{r^2(\sigma-3\rho)g}{\eta}$

20. A capillary of the shape as shown is dipped in a liquid. Contact angle between the liquid and the capillary is 0° and effect of liquid inside the meniscus is to be neglected. T is surface tension of the liquid, r is radius of the meniscus, g is acceleration due to gravity and ρ is density of the liquid then height h in equilibrium is

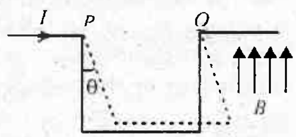


(a) greater than $2T/r\rho g$ (b) equal to $2T/r\rho g$

(c) less than $2T/r\rho g$

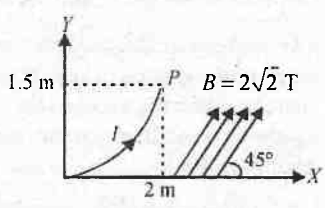
(d) of any value depending upon act.

21. As shown in the figure, three sided frame is pivoted at P and Q and hangs vertically. Its sides are of same length and have a linear density of $\sqrt{3}$ kg/m. A current of $10\sqrt{3}$ ampere is sent through the frame, which is in a uniform magnetic field of 2 T directed upwards as shown. Then angle through which the frame will be deflected in equilibrium is (Take $g = 10$ m/s^2)



(a) 30° (b) 45° (c) 60° (d) 90°.

22. A parabolic wire as shown in the figure is located in x-y plane and carries a current $I = 10$ amp. A uniform magnetic field of intensity $2\sqrt{2}$ T, making an angle of 45° with x-axis exists throughout the plane. If the co-ordinates of end point P of wire are (2 m, 1.5 m), then the total force acting on the wire is



(a) $40 \text{ N } \hat{k}$ (b) $10 \text{ N } \hat{k}$

(c) $-10 \text{ N } \hat{k}$ (d) $-40 \text{ N } \hat{k}$.

23. The gas law PV/T = constant for a given amount of a gas is true for

(a) isothermal change only

(b) adiabatic change only

(c) both isothermal & adiabatic changes

(d) neither isothermal nor adiabatic change.

24. A hot black body emits the energy at the rate of 16 J m^{-2} s^{-1} and its most intense radiation corresponds to 20,000 Å. When the temperature of this body is further increased and its most intense radiation corresponds to 10,000 Å, then the energy radiated in Jm^{-2} s^{-1} will be

(a) 4 (b) 1 (c) 64 (d) 256

25. A wall is made of two layers A and B of the same thickness but different materials. The thermal conductivity of A is twice that of B. In steady state, the temperature difference across the wall is 36°C. The temperature difference across the layer A is

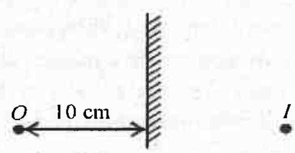
(a) 6° C (b) 12° C (c) 18° C (d) 24° C.

26. An ideal monoatomic gas initially at 300 K undergoes an isobaric expansion at a pressure of 2.5 kPa. If the volume increases from 1 m^3 to 3 m^3, then heat added to the gas and its final temperature respectively are

(a) 12500 J, 450 K (b) 12500 J, 600 K

(c) 12500 J, 900 K (d) 25000 J, 1200 K.

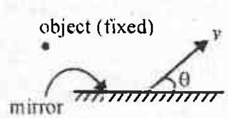
27. A plane mirror forms image I of an object O kept 10 cm from the mirror. It is found that when a planoconcave thin lens is placed in front of and in contact with the mirror (plane surface of lens in contact with mirror), the position of image formed by plane mirror does not change. Then the refractive index of lens and radius of curvature of its curved surface are respectively



(a) 1.5, 10 cm (b) 2.5, 10 cm

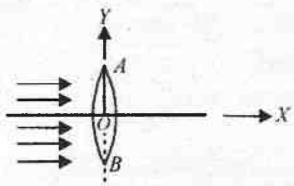
(c) $\sqrt{2}$, 10 cm (d) all of these are possible

28. An object and a plane mirror are shown in figure. Mirror is moved with velocity v as shown. The velocity of image is



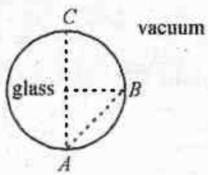
(a) $2v\sin\theta$ (b) $2v$
(c) $2v\cos\theta$ (d) none of these

29. Monochromatic light rays parallel to X-axis strike a convex lens AB. If the lens oscillates such that AB tilts upto a small angle θ (in radian) on either side of Y-axis, then the amplitude of oscillation of image will be (f = focal length of the lens)



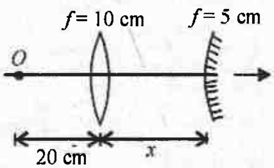
(a) $f\sec\theta$ (b) $f\sec^2\theta$
(c) $f\theta^2/2$ (d) the image will not move.

30. It is found that all electromagnetic signals sent from A towards B reach point C. The speed of electromagnetic signals in glass cannot be



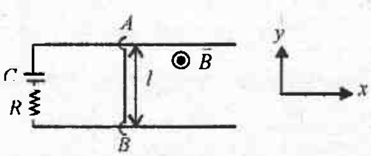
(a) 1.0×10^8 m/s
(b) 2.4×10^8 m/s
(c) 2×10^7 m/s (d) 4×10^7 m/s

31. Figure shows an object placed in front of a lens of focal length 10 cm, at a distance 20 cm from the lens. On the other side, a convex mirror (f = 5 cm) (with same principle axis as that of lens) is placed such that all light rays after refracting through lens strike the mirror simultaneously. The distance between the mirror and the lens is



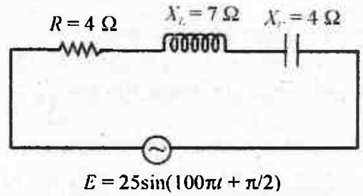
(a) 5 cm (b) 10 cm
(c) 30 cm (d) cannot be determined

32. A conducting rod AB moves parallel to x-axis in the x-y plane. A uniform magnetic field B pointing out of the plane as shown in the figure. Required force to maintain a constant speed v of the rod is given by (initially capacitor is uncharged)



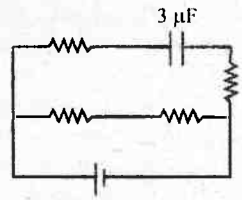
(a) $\frac{v_0B^2l^2}{R}e^{-t/RC}$ (b) $\frac{v_0B^2l^2}{R}$
(c) $\frac{v_0B^2l^2}{R}(1-e^{-t/RC})$ (d) $\frac{v_0B^2l^2}{R}e^{2t/RC}$

33. In the series LCR circuit as shown in figure, the heat developed in 80 seconds and amplitude of wattless current is



(a) 4000 J, 3A
(b) 8000 J, 3A
(c) 4000 J, 4A (d) 8000 J, 5A

34. In the given circuit, the potential difference across the capacitor (in steady state) is 24 V. Each resistance is of 6 Ω. If the cell is ideal, then emf of the cell is



(a) 30 V
(b) 9 V
(c) 12 V (d) 40 V.

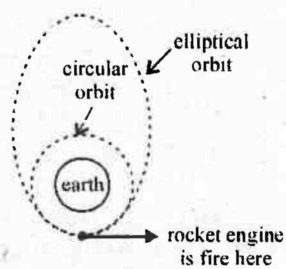
35. A loop of a string of mass per unit length μ and radius R is rotated about an axis passing through centre perpendicular to the plane with an angular velocity ω. A small disturbance is created in the loop having the same sense of rotation. The linear speed of the disturbance for a stationary observer is
(a) ωR (b) $2\omega R$
(c) $3\omega R$ (d) zero.

PASSAGE -1 : (Read the following passage and answer the questions numbered 36 to 40. They have only one correct option)

Changing from a circular to an elliptical orbit

Let us identify the system as the spacecraft and the earth but not the portion of the fuel in the spacecraft that we use to change the orbit. In a given orbit, the mechanical energy of the spacecraft - earth system is given by $E = -GMm/2r$.

This energy includes the kinetic energy of the spacecraft and the potential energy associated with the gravitational force between the spacecraft and the earth.



If the rocket engines are fired, the thrust force moves the spacecraft through a displacement. As a result, the mechanical energy of the spacecraft - earth system increases. The spacecraft has a new higher energy but is constrained to be in an orbit that includes the original starting point. It cannot be in a higher energy circular orbit having a

larger radius because this orbit would not contain the starting point. The only possibility is that the orbit is elliptical as shown in the figure.

$$E = -\frac{GMm}{2a}$$

Above equation gives the energy of the spacecraft- earth system for an elliptical orbit where a is semimajor axis. Thus if we know the new energy of the orbit, we can find the semi-major axis of the elliptical orbit. Conversely, if we know the semi-major axis of an elliptical orbit we would like to achieve, we can calculate how much additional energy is required from the rocket engines.

A spacecraft is moving in a circular orbit around the earth (radius 6400 km), at a height of 300 km from the surface. To place the spacecraft in an elliptical orbit, the magnitude of the mechanical energy of the spacecraft-earth system is decreased by 10.0%.

36. If the spacecraft-earth system had initial energy $(-E_0)$, then the total mechanical energy of the system after firing the rocket will be

(a) $-1.1E_0$ (b) $-0.9E_0$
(c) $-E_0$ (d) none of these.

37. Semimajor axis of the new elliptical orbit is

(a) 7437 km (b) 6700 km
(c) 7370 km (d) none of these.

38. The maximum distance from the centre of the earth to the spacecraft is

(a) 6700 km (b) 8174 km
(c) 7437 km (d) 7874 km.

39. Maximum height of the spacecraft above the surface of the earth will be

(a) 970 km (b) 1474 km
(c) 300 km (d) 1774 km.

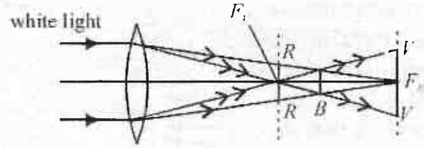
40. Minimum distance of the spacecraft from the surface of the earth is

(a) 900 km (b) 1474 km
(c) 300 km (d) 1774 km.

PASSAGE # 2 : (Read the following passage and answer the questions numbered 41 to 45. They have only one correct option)

Chromatic Aberration

The image of a white object in white light formed by a lens is usually coloured and blurred. This defect of image is called chromatic aberration and arises due to the fact that focal length of a lens is different for different colours. As μ of lens is maximum for violet while minimum for red, violet is focused nearest to the lens while red farthest from it as shown in figure.



As a result of this, in case of convergent lens if a screen is placed at F_V centre of the image will be violet and focused while sides are red and blurred. While at F_R, reverse is the case, *i.e.*, centre will be red and focused while sides violet and blurred. The difference between f_V and f_R is a measure of the longitudinal chromatic aberration (*L.C.A*), *i.e.*,

$$L.C.A. = f_R - f_V = -df \text{ with } df = f_V - f_R \quad \ldots (1)$$

However, as for a single lens,

$$\frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \quad \ldots (2)$$

$$\Rightarrow \quad -\frac{df}{f^2} = d\mu\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \quad \ldots (3)$$

Dividing eqn. (3) by (2);

$$-\frac{df}{f} = \frac{d\mu}{(\mu - 1)} = \omega$$

$$\left[\text{as } \omega = \frac{d\mu}{(\mu - 1)}\right] = \text{dispersive power} \quad \ldots (4)$$

And hence, from eqns. (1) and (4),

$$L.C.A. = -df = \omega f$$

Now, as for a single lens neither f nor ω can be zero, we cannot have a single lens free from chromatic aberration.

Condition of Achromatism :

In case of two thin lenses in contact

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} \quad i.e. \quad -\frac{dF}{F^2} = -\frac{df_1}{f_1^2} - \frac{df_2}{f_2^2}$$

The combination will be free from chromatic aberration if $dF = 0$

$$i.e., \quad \frac{df_1}{f_1^2} + \frac{df_2}{f_2^2} = 0$$

which with the help of eqn. (4) reduces to

$$\frac{\omega_1 f_1}{f_1^2} + \frac{\omega_2 f_2}{f_2^2} = 0 \quad i.e., \quad \frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0 \quad \ldots (5)$$

This condition is called condition of achromatism (for two thin lenses in contact) and the lens combination which satisfies this condition is called achromatic lens, From this condition, *i.e.*, from eqn. (5) it is clear that in case of achromatic doublet :

(1) The two lenses must be of different materials.

Since, if $\omega_1 = \omega_2$, $\frac{1}{f_1} + \frac{1}{f_2} = 0$

i.e., $\frac{1}{F} = 0$ or, $F = \infty$

i.e., combination will not behave as a lens, but as a plane glass plate.

(2) As ω_1 and ω_2 are positive quantities, for eqn. (5) to hold, f_1 and f_2 must be of opposite nature, *i.e.*, if one of the lenses is converging the other must be diverging.

(3) If the achromatic combination is convergent,

$f_C < f_D$ and as $-\frac{f_C}{f_D} = \frac{\omega_C}{\omega_D}$, $\omega_C < \omega_D$

i.e., in a convergent achromatic doublet, convex lens has lesser focal length and dispersive power than the divergent one.

41. Chromatic aberration in the formation of images by a lens arises because :
(a) of non-paraxial rays
(b) the radii of curvature of the two sides are not same.
(c) of the defect in grinding.
(d) the focal length varies with wavelength.

42. Chromatic aberration of a lens can be corrected by
(a) providing different suitable curvatures of its two surfaces.
(b) proper polishing of its two surfaces.
(c) suitably combining it with another lens.
(d) reducing its aperture.

43. A combination is made of two lenses of focal lengths f and f' in contact, the dispersive powers of the materials of the lenses are ω and ω'. The combination is achromatic when
(a) $\omega = \omega_0$, $\omega' = 2\omega_0$, $f' = 2f$
(b) $\omega = \omega_0$, $\omega' = 2\omega_0$, $f' = f/2$
(c) $\omega = \omega_0$, $\omega' = 2\omega_0$, $f' = -f/2$
(d) $\omega = \omega_0$, $\omega' = 2\omega_0$, $f' = -2f$.

44. The dispersive power of crown and flint glasses are 0.02 and 0.04 respectively. An achromatic converging lens of focal length 40 cm is made by keeping two lenses, one of crown glass and the other of flint glass, in contact with each other. The focal lengths of the two lenses are
(a) 20 cm and 40 cm (b) 20 cm and –40 cm
(c) –20 cm and 40 cm (d) 10 cm and –20 cm.

45. Chromatic aberration in a spherical concave mirror is proportional to
(a) f (b) f^2
(c) $1/f$ (d) none of these.

PASSAGE - 3 : (Read the following passage and answer the questions numbered 46 to 50. They have only one correct option)

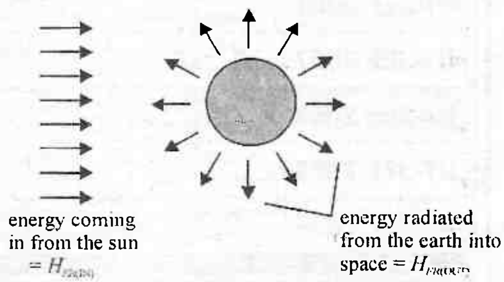
Energy balance for the earth

Energy arrives at the earth by electromagnetic radiations from the sun. This energy is absorbed by the surface of the earth and reradiated out into space according to Stefen's law. The only type of energy in the system that can change due to radiation is internal energy. Let us assume that any change in temperature of the earth is so small over a time interval that we can approximate the change in internal energy as zero.

Thus $H_{ER(IN)} + H_{ER(OUT)} = 0$

$\Rightarrow$ $H_{ER(IN)} = -H_{ER(OUT)}$.

Where the IN and the OUT refer to energy transfers across the boundary of the system of the earth, as shown in figure.



The rate of energy transfer per unit area from the sun is approximately 1340 W/m^2 at the top of atmosphere, which is called solar constant I_s. Not all of the radiation arriving at the top of the atmosphere reaches the ground. A fraction approximately 30% of it is reflected from clouds and the ground and escapes back into space. Stephen's law can be used to express the outgoing power, assuming that the earth is a perfect emmiter. Using the equation and the facts, calculation shows that result is significantly lower than the average global temperature 288 K, determined using actual measurements. This difference indicated that a major factor was left out of the analysis.

This is the thermodynamic effect of the atmosphere, which results in the additional energy being trapped in the system of the earth and raising the temperature. The energy balance concept is certainly valid and the earth, as a system, must emit energy at the same rate as it absorbs. Thus the value obtained using the energy

balance concept is the temperature associated with radiation leaving the top of the atmosphere - it is not the temperature at the surface of the earth.

46. If radius of the earth is 6400 km, then net input power received by surface of the earth is nearly equal to
(a) 1.2×10^{17} watt (b) 1.7×10^{17} watt
(c) 4.8×10^{17} watt (d) 3.6×10^{17} watt

47. According to the concept of energy balance, the temperature of the earth should be
(a) 312 K (b) 296 K (c) 254 K (d) 288 K

48. At moon, if solar constant $I_s = 567$ W/m^2, then its equilibrium temperature is approximately equal to
(a) 300 K (b) 224 K (c) 254 K (d) 288 K

49. I. Energy balance concept can correctly predict temperature of surface of a planet/satellite provided there is no atmosphere on the planet/satellite.
II. If energy balance concept is used for planets/satellite with atmosphere, it can find out temperature of top of the atmosphere, not of the surface.
(a) both I and II statements are correct
(b) both I and II statements are incorrect
(c) statement I is correct and II is incorrect
(d) statement I is incorrect and II is correct

50. If solar constant for earth and the mars is I_e and I_m respectively, then the ratio of average sun-earth distance and sun-mars distance is

(a) $\sqrt{\dfrac{I_m}{I_e}}$ (b) $\dfrac{I_m}{I_e}$ (c) $\left(\dfrac{I_m}{I_e}\right)^2$ (d) $\sqrt{\dfrac{I_e}{I_m}}$

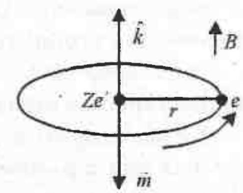
PASSAGE - 4 : (Read the following passage and answer the questions numbered 51 to 55. They have only one correct option).

Magnetic Properties of Matter

All magnetic fields are due to electric charges in motion. If for example, one were to examine a piece of magnetic material in an atomic scale, he would find tiny current elements created by to distinct and independent processes : Electrons orbiting around nuclei and spinning on their axes. We may treat these current loops as magnetic dipoles, and thus conclude that each electron constitutes a magnetic dipole. But these electrons within a given atom lock together in pairs with opposing spins, and thus effectively neutralise the magnetic moment of each other. Only atoms and molecules with an odd number of electrons may possess a net magnetic diploe moment. Such materials are said to be paramagnetic (for example : Mn^{2+}). Materials in which individual atoms or molecules have no net magnetic dipole moment are said to be diamagnetic (for example : Cu^{+}).

Even if an atom has a net magnetic moment, a finite sample of the material will have zero magnetic moment because of random orientation of the atoms. But when a magnetic field is applied, a net alignment of magnetic dipole occurs and the medium becomes magnetically polarized or magnetized. Unlike electric polarization which is always in the same direction as $\bar{E}$, magnetisation can be both parallel (paramagnets) and antiparallel (diamagnets) to $\bar{B}$.

A few materials (called ferromagnetic in reference to their most common example, iron) retain substantial magnetisation even after the external field has been removed - for these magnetisation is dependent not just on the present field but also on the magnetic history of the object.



When placed in an external magnetic field paramagnetic substances acquire magnetisation due to alignment of atomic dipoles. But what about diamagnetic materials?

Consider an electron revolving in its orbit with a magnetic field applied perpendicular to its plane of motion. Whereas the centripetal acceleration (v^2/r) is ordinarily sustained by electrical forces alone,

$$\frac{m_e v^2}{r} = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2}$$

Now the magnetic force also has a role to play, thus changing the orbital velocity to v'

$$\frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2} + ev'B = \frac{m_e v'^2}{r}$$

(under the conditions shown in the above diagram the new speed v' is greater than v. If B were in opposite direction magnetic force would be opposite to the electric force and thus v' would be less than v).

$$ev'B = \frac{m_e}{r}(v'^2 - v^2) = \frac{m_e}{r}(v' + v)(v' - v)$$

assuming $(v' - v) = \Delta v \ll v$, we get $\Delta v = \dfrac{erB}{2m_e}$

Orbital magnetic moment being directly proportional to orbital angular momentum, a change in orbital speed means a change in orbital magnetic moment.

$$\Delta m = -\frac{1}{2}e\Delta v r\hat{k} = \frac{-e^2 r^2 \vec{B}}{4m_e}$$

Notice that this, change is magnetic moment is opposite to the direction of the applied field. In ordinary unmagnetised matter all electron orbits are randomly oriented and thus the orbital magnetic moments cancel out. But in presence of magnetic field each atom picks up a little extra dipole moment and these increments are all antiparallel to the field. This is the mechanism responsible for diamagnetism. Evidently it is a universal phenomenon affecting all atoms. However, it is typically much weaker than paramagnetism and is therefore observed mainly in atoms with paired electrons where paramagnetism is absent.

51. The magnetic moment of an electron comprises of two factors. A spin component and an orbital component. Choose the correct option.

(a) only the spin component is responsible of paramagnetism
(b) only the orbital component is responsible for paramagnetism
(c) both spin and orbital component together account for paramagnetism
(d) both spin and orbital component together account for diamagnetism.

52. Choose the incorrect statement.

(a) all ferromagnetic materials are diamagnetic too
(b) all ferromagnetic materials are paramagnetic too
(c) all paramagnetic materials are diamagnetic too
(d) all diamagnetic materials are paramagnetic too

53. The orbital magnetic moment of an electron is directly proportional to the orbital angular momentum $M = K \cdot L$. The value of K (according to the passage) is

(a) $e/2m_e$ (b) e/m_e (c) $2e/m_e$ (d) $3m_e/2$.

54. The fractional change in orbital magnetic moment of an electron in Li^{2+} revolving in an orbit of radius r when exposed to a magnetic field of 1 tesla perpendicular to its orbital plane is

(a) $\sqrt{\frac{\pi\varepsilon_0 r^3}{3m_e}}$ (b) $\sqrt{\frac{\pi\varepsilon_0 r}{3m_e}}$

(c) $\sqrt{\frac{4\pi\varepsilon_0 r}{3m_e}}$ (d) $\sqrt{\frac{\pi\varepsilon_0 r^2}{3m_e}}$

55. Samples of manganese chloride ($MnCl_2$), cuprous oxide Cu_2O and metallic iron were picked up from a meteor X by a suitable space probe and send back to earth. Similar samples picked from another meteor Y were also send back to earth. When these samples were exposed to the same magnetic field at a laboratory on earth, choose the incorrect statement :

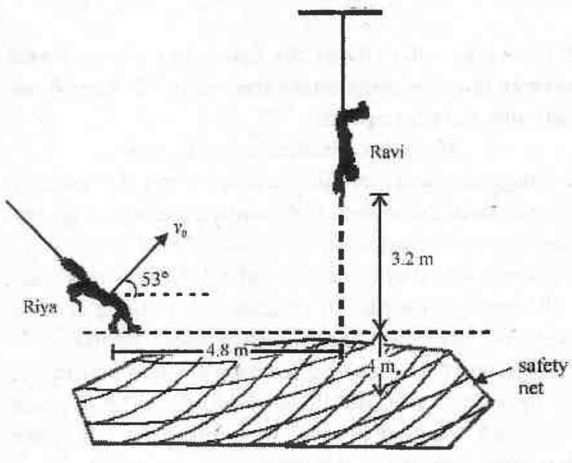
(a) $MnCl_2$ from both X and Y will acquire the same magnetisation
(b) Cu_2O from both X and Y will acquire the same magnetisation
(c) iron from both X and Y will acquire the same magnetisation
(d) none of these

PASSAGE - 5 : (Read the following passage and answer the questions numbered 56 to 60. They have only one correct option)

Circus Act

A new circus act was developed by Gemini circus. Riya (a circus girl) swings from a trapeze, projects herself at an angle of 53° as shown and supposed to be caught by Ravi, whose hands are 3.2 m above and 4.8 m horizontally from her launch point.

Once Riya is projected, she moves freely under gravity. She requires certain minimum velocity v_0 to reach Ravi. This velocity may be evaluated by using equation of motion in 2-D. Once Riya reaches to Ravi, she is caught by Ravi. Now both move with same speed upward and both swing around suspension point O.



In order to safe guard their lives, a safety net is provided 4 m below the launching point of Riya. For all the following calculations take g = 10 m/s².

56. In order to just reach Ravi, the initial speed of Riya should be equal to

(a) 45 km/hr (b) 30 km/hr
(c) 36 km/hr (d) 24 km/hr

57. In the above problem, at the instant when Riya reaches to Ravi, the magnitude and direction of her velocity is

(a) 21.6 km/hr, at 37° upward from horizontal.
(b) 21.6 km/hr, in horizontal direction.
(c) 16.2 km/hr, at 37° upward from horizontal.
(d) 16.2 km/hr, in horizontal direction.

58. In the above problem, if mass of Ravi is $2m$ and mass of Riya is m, then when riya is caught by Ravi both move together with the speed equal to

(a) 9 km/hr (b) 6 km/hr
(c) 7.2 km/hr (d) 4.8 km/hr

59. If both move together further and both of them are considered as one mass system of $3m$. Effective distance of this one mass system from suspension point is assumed to be 1 meter, then angle through which they deflect will be

(a) 30° (b) 37° (c) 53° (d) 60°

60. In their debut performance, once Ravi misses the Riya completely as she flies past. The horizontal distance through which Riya moves from the initial launch point before landing in the safety net 4 m below her initial launch point is

(a) 10 m (b) 9 m (c) 12 m (d) 9.6 m

ANSWERS

1. (d)	2. (d)	3. (c)	4. (b)	5. (d)
6. (d)	7. (d)	8. (d)	9. (b)	10. (b)
11. (a)	12. (b)	13. (b)	14. (a)	15. (b)
16. (c)	17. (a)	18. (b)	19. (b)	20. (b)
21. (b)	22. (b)	23. (c)	24. (d)	25. (b)
26. (c)	27. (d)	28. (a)	29. (c)	30. (b)
31. (b)	32. (a)	33. (a)	34. (a)	35. (b)
36. (b)	37. (a)	38. (b)	39. (d)	40. (c)
41. (d)	42. (c)	43. (d)	44. (b)	45. (b)
46. (a)	47. (c)	48. (b)	49. (a)	50. (a)
51. (a)	52. (d)	53. (a)	54. (a)	55. (c)
56. (c)	57. (b)	58. (c)	59. (b)	60. (c)

Note : For detailed solutions please log on to our website www.resonance.ac.in

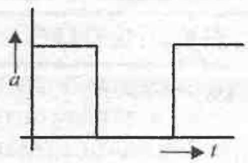
Very Similar
MODEL TEST PAPER
for AIEEE-2006

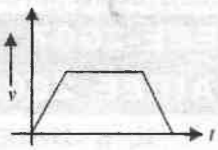
Exam on 30th April 2006

1. The dimensional formula representation for impedance of A.C. circuit is

(a) $[M^0L^2T^{-3}]$ (b) $[ML^2T^{-3}A^{-2}]$
(c) $[ML^2T^{2}A^{-1}]$ (d) $[ML^1T^{-3}A^2]$.

2. Figure shows the acceleration-time graph of a particle. Which of the following represents the corresponding velocity-time graph?



(a)


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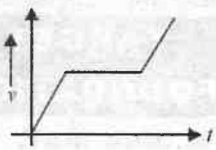
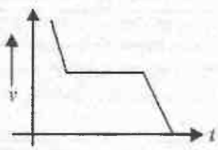
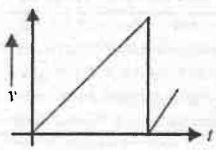


(c)


(d)


3. A train of length 200 m travelling at 30 ms^{-1} overtakes another train of length 300 m travelling at 20 ms^{-1}. The time taken by the first train to pass the second is

(a) 20 s (b) 30 s (c) 40 s (d) 50 s.

4. If $\vec{A}\times\vec{B}=0$ and $\vec{B}\times\vec{C}=0$, then the value of $\vec{A}\times\vec{C}$ is

(a) 0 (b) $AC\sin\theta\hat{n}$.
(c) $AC\cos\theta$ (d) $AB\tan\theta$.

5. An aeroplane flying at a constant speed releases a bomb. As the bomb moves away from the aeroplane, it will

(a) always be vertically below the aeroplane if the aeroplane was flying horizontally
(b) always be vertically below the aeroplane if the aeroplane was flying at an angle of 45° to the horizontal
(c) always be vertically below the aeroplane
(d) gradually fall behind the aeroplane if the aeroplane was flying horizontally.

6. Two weights w_1 and w_2 are connected by a light thread which passes over a light smooth pulley. If the pulley is raised upwards with an acceleration equal to g, then the tension in the thread will be

(a) $\frac{2w_1w_2}{w_1+w_2}$ (b) $\frac{w_1w_2}{w_1+w_2}$
(c) $\frac{4w_1w_2}{w_1+w_2}$ (d) $\frac{4w_1w_2}{w_1-w_2}$.

7. A beaker containing water is lying on the pan of a spring balance. If one dips his finger in the water without touching the beaker, then the reading of the spring balance will

(a) become zero (b) not change
(c) decrease (d) increase.

8. A person standing on the floor of a lifts drops a coin. The coin touches the floor after t_1 second if the lift is at rest and after t_2 second if the lift is moving with a uniform velocity v upwards, then

(a) $t_1 = t_2$ (b) $t_1 > t_2$
(c) $t_1 < t_2$ (d) none of these.

9. Two billiard balls of the same size and mass are in contact on a billiard table. A third ball of the same size and mass strikes them symmetrically and remains at rest after the impact. The coefficient of restitution between the balls is

(a) 2/3 (b) 2/4.1 (c) 1/7 (d) 1/8.

10. The linear momentum of a body is increased by 50%. The kinetic energy will be increased by

(a) 25% (b) 50% (c) 100% (d) 125%.

11. Three identical cars A, B and C are moving at the same speed on three bridges. The car A goes on a plane bridge, B on a bridge convex upward and C goes on a bridge concave upward. Let F_A, F_B and F_C be the normal

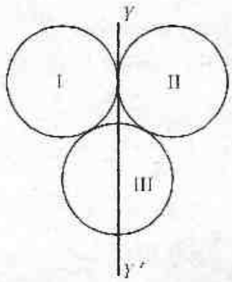
forces exerted by the cars on the bridges when they are at the middle of the bridges, then

(a) F_A is maximum of the three forces
(b) F_B is maximum of the three forces
(c) F_C is maximum of the three forces
(d) $F_A = F_B = F_C$.

12. If r denotes the distance between the sun and the earth, then the angular momentum of the earth around the sun is

(a) $\propto \sqrt{r}$ (b) $= mr$ (c) m^2r (d) $\propto r^{3/2}$.

13. Three identical rings, each of mass M and radius R are arranged as shown in figure. The moment of inertia of the arrangement about YY' is



(a) $\frac{1}{2}MR^2$
(b) MR^2
(c) $\frac{5}{2}MR^2$ (d) $\frac{7}{2}MR^2$

14. Two planets have radii in the ratio $x : y$ and density in the ratio $m : n$. The acceleration due to gravity g is in the ratio

(a) $nx : my$ (b) $ny : mx$
(c) $mx : ny$ (d) $my : nx$.

15. A tunnel is dug along a diameter of the earth. If M_e and R_e are the mass and radius respectively of earth, then the force on a particle of mass m placed in the tunnel at a distance r from the centre is

(a) $\frac{GM_e m}{R_e^3} r$ (b) $\frac{GM_e m}{R_e^3 r}$

(c) $\frac{GM_e m R_e^3}{r}$ (d) $\frac{GM_e m}{R_e^2} r$

16. A heavy stone is attached to a thin wire and is whirled in a vertical circle. The wire is most likely to break when the stone is at the

(a) highest point (b) lowest point
(c) middle-point, between lowest and highest points, of the circle
(d) position where the wire makes an angle of 45° with the diameter.

17. The Young's modulus of brass and steel are 10×10^{10} Nm^{-2} and 2×10^{11} Nm^{-2} respectively. A brass wire and a steel wire of the same length are extended by 1 mm under the same force. The radii of the brass and steel wires are R_B and R_S respectively. Then

(a) $R_S = \sqrt{2}R_B$ (b) $R_S = \frac{R_B}{\sqrt{2}}$

(c) $R_S = 4R_B$ (d) $R_S = \frac{R_B}{4}$.

18. A body floats with 1/3 of its volume outside water and 3/4 of its volume outside another liquid. The density of other liquid is

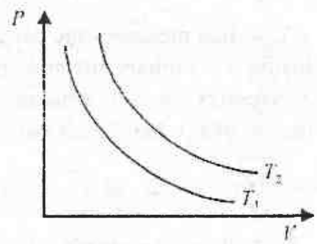
(a) $\frac{9}{4}$ g cm^{-3} (b) $\frac{4}{9}$ g cm^{-3}

(c) $\frac{8}{3}$ g cm^{-3} (d) $\frac{3}{9}$ g cm^{-3}

19. On mixing the salt in water, the surface tension of water will

(a) increase (b) decrease
(c) remain unchanged (d) none of these.

20. Figure shows the pressure P versus volume V graphs for a certain mass of a gas at two constant temperatures T_1 and T_2. Which of the following inference is correct?



(a) $T_1 = T_2$ (b) $T_1 > T_2$
(c) $T_1 < T_2$
(d) no inference can be drawn due to insufficient information.

21. The temperature, at which r.m.s. velocity of helium molecules is equal to the r.m.s. velocity of hydrogen molecules at NTP, is

(a) 100 K (b) 300 K (c) 502 K (d) 546 K.

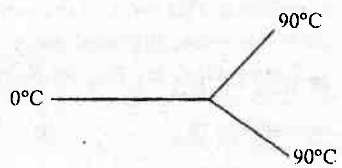
22. The temperature of equal masses of three different liquids A, B and C are 12°C, 19°C and 28°C respectively. The temperature when A and B are mixed is 16°C and when B and C are mixed is 23°C. The temperature when A and C are mixed is

(a) 18.2°C (b) 20.3°C (c) 22.2°C (d) 24.2°C.

23. 540 g of ice at 0°C is mixed with 540 g of water at 80°C. The final temperature of mixture is

(a) 0°C (b) 40°C
(c) 80°C (d) less than 0°C.

24. Three rods made of the same material and having the same cross-section have been joined as shown in figure. Each rod is of the same length. The left and right ends are kept at 0°C and 90°C respectively. The temperature of the junction of the three rods will be



(a) 45°C (b) 60°C (c) 30°C (d) 20°C.

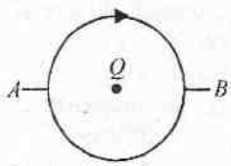
25. Two tuning forks of frequencies 256 Hz and 258 Hz are sounded together. The time interval between consecutive maxima heard by the observer is
(a) 2 s (b) 0.5 s (c) 250 s (d) 252 s.

26. The displacement y of a particle executing periodic motion is given by $y = 4\cos^2(1/2\ t)\sin(1000t)$. This expression may be considered to be a result of the superposition of independent harmonic motions
(a) two (b) three (c) four (d) five.

27. A man measures the period of a simple pendulum inside a stationary lift and finds to be T s. If the lift accelerates upwards with an acceleration $g/4$, then the period of the pendulum will be

(a) $\frac{2T}{\sqrt{5}}$ (b) $2T\sqrt{5}$ (c) T (d) $T/4$.

28. A charge Q is placed at the centre of a circle of radius R. The work done in moving a charge q from A to B so as to complete a semicircle is



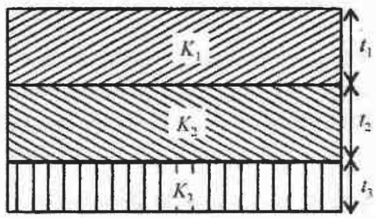
(a) zero (b) $\frac{Qq}{4\varepsilon_0 R}$

(c) $\frac{Qq}{2\varepsilon_0 R}$ (d) $\frac{Qq}{4\varepsilon_0 R^2}$.

29. What is the total flux of electrostatic field due to a charge of one coulomb?
(a) ε_0 (b) $1/\varepsilon_0$ (c) ε_0^2 (d) $1/\varepsilon_0^2$.

30. A parallel-plate capacitor is connected to a battery that has a constant terminal voltage. If the capacitor plates are pulled apart,
(a) the electric field decreases and the charge on the plates also decreases
(b) the electric field remains constant but the charge on the plate increases
(c) the electric field remains constant but the charge on the plate decreases
(d) the electric field increases but the charge on the plate decreases.

31. A parallel plate capacitor is filled with three dielectric of thickness t_1, t_2 and t_3 such that $t_1 + t_2 + t_3 = d$. Then capacitance of the system is (given that plate area = A)

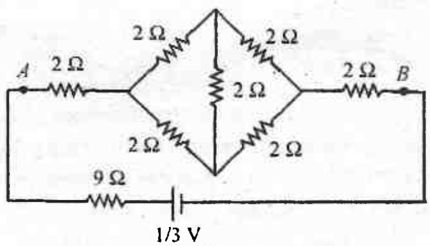


(a) $\frac{A\varepsilon_0}{\left(\frac{t_1}{K_1}+\frac{t_2}{K_2}+\frac{t_3}{K_3}\right)}$ (b) $\left(\frac{K_1K_2K_3}{t_1+t_2+t_3}\right)A\varepsilon_0$

(c) $\left(\frac{2K_1K_2K_3}{t_1+t_2+t_3}\right)A\varepsilon_0$ (d) $\left(\frac{A\varepsilon_0}{d}\right)$

32. A wire l = 8.00 m long, of uniform cross-sectional area A = 8.00 mm², has a conductance of G = 2.45 Ω^{-1}. What is the resistivity of the material of the wire?
(a) 2.1×10^{-7} S (b) 3.1×10^{-7} S
(c) 4.1×10^{-7} S (d) 5.1×10^{-7} S.

33. The potential difference between A and B in the circuit shown is



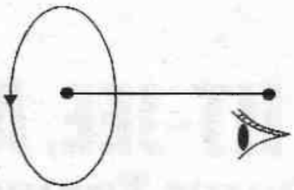
(a) $\frac{4}{15}$ V (b) $\frac{7}{15}$ V

(c) $\frac{2}{15}$ V (d) $\frac{8}{15}$ V

34. There are n exactly identical resistors each having resistance R. The resultant resistance when joined in parallel is λ, then on connecting them in series the resistance will come out be
(a) $\frac{\lambda}{n^2}$ (b) $n^2\lambda$ (c) $\frac{\lambda}{n^3}$ (d) $n^3\lambda$.

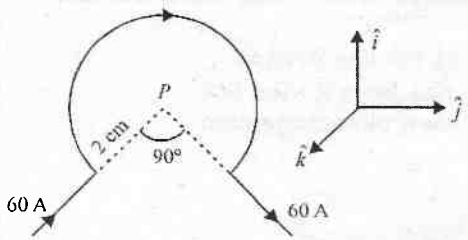
35. Ohm's law is not applicable in
(a) diode (b) transistors
(c) radio waves (d) all of these.

36. A current passes through a coil in the anti-clockwise direction. The magnetic field at a point on the axis of the coil is



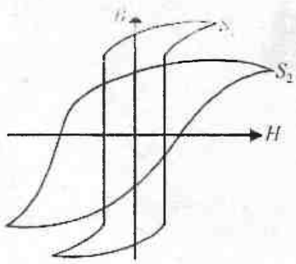
(a) perpendicular to the plane of the coil
(b) perpendicular to the axis of the coil
(c) along the axis towards the centre of the coil
(d) along the axis away from the centre of coil.

37. The wire shown in the figure carries a current of 60 A. The field P if radius is 2 cm will be



(a) $-45\pi \times 10^{-5}\hat{k}$ tesla (b) $-45\pi \times 10^{-6}\hat{k}$ tesla
(c) $-45\pi \times 10^{-3}\hat{k}$ tesla (d) $-45\pi \times 10^{-4}\hat{k}$ tesla.

38. The B-H curves S_1 and S_2 in the figure are associated with



(a) a diamagnetic and paramagnetic substance respectively
(b) a paramagnetic and ferromagnetic substance respectively
(c) soft iron and steel respectively
(d) steel and soft iron respectively.

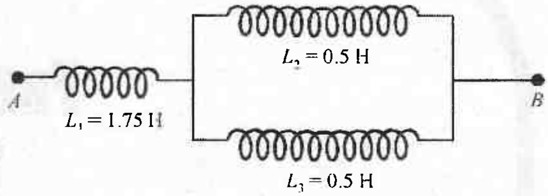
39. A proton moving with a constant velocity passes through a region of space without any change in velocity. If E and B represent the electric and magnetic fields respectively, this region of space may not have

(a) $E = 0, B \neq 0$ (b) $E \neq 0, B = 0$
(c) $E \neq 0, B \neq 0$ (d) $E = 0, B = 0$.

40. Which of the following pairs of space and time varying E and B fields would generate a plane electromagnetic wave travelling in the Z-direction?

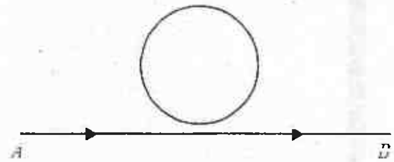
(a) E_X, B_Y (b) E_X, B_X (c) E_X, B_Z (d) E_Z, B_X.

41. Three pure inductances a.c. connected as shown in figure. The equivalent inductance of the circuit is



(a) 2.75 H (b) 2.25 H
(c) 2.00 H (d) 1.75 H.

42. An electron moves along the line AB which lies in the same plane as a circular loop of conducting wire as shown in the figure. What will be the direction of current induced, if any, in the loop?



(a) no current will be induced
(b) the current will be clockwise
(c) the current will be anticlockwise
(d) the current will change direction as the electron passed by.

43. A coil of 150 ohm and inductance 1.0 henry is connected across an alternating voltage of frequency $150/2\pi$ Hz. The phase difference between the voltage and current in the circuit is

(a) $\pi/2$ (b) $\pi/3$ (c) zero (d) $\pi/4$.

44. If A is the amplitude of the wave coming from a line source at a distance r, then

(a) $A \propto r^{-2}$ (b) $A \propto r^{-1}$
(c) $A \propto r^{2}$ (d) $A \propto r^{1}$.

45. In Young's double slit experiment, monochromatic light is used to illuminate two slits A and B. Slit A being on the upper side of the horizontal plane. Interference fringes are observed on a screen placed in front of the slits. Now if a thin glass plate is placed normally in the path of the beam, coming from slit A, then

(a) fringe width increases
(b) fringe width decreases
(c) there is no change in fringe width
(d) fringes disappear.

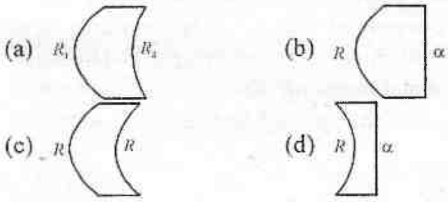
46. Out of the following four waves which of the two can produce interference?

(i) $y_1 = a_1\sin\omega t$ (ii) $y_2 = a_2\sin 2\omega t$

(iii) $y_3 = a_3\cos\omega t$ (iv) $y_4 = a_4 \sin\left(\omega t + \frac{\pi}{3}\right)$

(a) (i) and (ii) (b) (i) and (iii)
(c) (ii) and (iv) (d) none of these.

47. Which one of the following spherical lenses does not exhibit dispersion? Radii of curvature of the surfaces of the lenses are as given in the diagram.



48. If illumination produced at a screen placed at a distance of 2 m from the lamp is 25 lux, then total luminous flux emitted by the lamp is

(a) 50 candela (b) 100 candela
(c) 150 candela (d) 300 candela.

49. If two lenses having powers +6 dioptre and –4 dioptre are placed in contact. Then nature and focal length of the combination will be

(a) concave, 50 cm (b) convex, 50 cm
(c) concave, 25 cm (d) convex, 25 cm.

50. Eye piece of an astronomical telescope has focal length of 5 cm. If angular magnification in normal adjustment is 10, then distance between eye piece and objective should be

(a) 15 cm (b) 35 cm (c) 55 cm (d) 75 cm.

51. Work function of aluminium is 4.2 eV. If two photons each of energy 3.5 eV strike an electron of aluminium then emission of electron

(a) will be possible
(b) depends on the smoothness of the surface
(c) will not be possible (d) none of these.

52. A proton and an α-particle are accelerated through same potential difference. Then ratio of the de-Broglie wavelengths λ_p and λ_α will be

(a) 2 (b) 1/2 (c) 1/3 (d) $(1/2)^{1/2}$.

53. If the radioactive decay constant of radium is 1.07×10^{-4} per year, then its half life period is approximately equal to

(a) 2520 years (b) 6475 years
(c) 7010 years (d) 8900 years.

54. Uranium-235 is used as nuclear fuel in a nuclear reactor having power level 1 MW. Amount of fuel needed in one year will be (given : energy released per fission = 200 MeV)

(a) 87 g (b) 103 g (c) 384 g (d) 148.5 g.

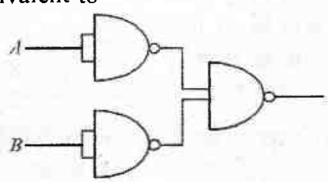
55. In a common base transistor amplifier, current gain is 0.98. On changing emitter current by 5 mA, collector current changes by

(a) 4.9 mA (b) 0.19 mA (c) 5.98 mA (d) 5.0 mA.

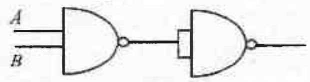
56. An intrinsic semiconductor behaves like insulator at

(a) 273 K (b) 100°C (c) 273°C (d) 0 K.

57. Combinations of NAND gates shows below are equivalent to



and



(a) AND and NOT gates respectively
(b) OR and AND gates respectively
(c) AND and OR gates respectively
(d) OR and NOT gates respectively.

58. When a silicon junction diode is forward biased by applying a voltage of 0.9 V, then current through diode is 55 mA at 27°C. The dc resistance of the circuit will be

(a) 5.3 ohm (b) 12.8 ohm
(c) 16.4 ohm (d) 23.8 ohm.

59. When 90% electrons emitted reach the collector, then collector current is found to be 9 mA. Then
(a) emitter current will be 8 mA
(b) emitter current will be 11 mA
(c) emitter current will be 9 mA
(d) base current will be 1 mA.

60. The T.V transmission tower in Delhi has a height of 240 m. The distance up to which the broadcast can be receive is (radius of earth = 6.4×10^6 m)

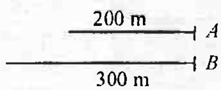
(a) 100 km (b) 60 km
(c) 55 km (d) 50 km.

SOLUTIONS

1. **(b) :** [Impedence] = [resistance]

$$= \left[\frac{V}{I}\right] = \frac{[ML^2T^{-2}]}{[AT][A]} = [ML^2T^{-3}A^{-2}].$$

2. **(b) :** Since acceleration is constant, therefore there is a uniform increase in velocity. So, the v-t graph is a straight line sloping upwards to the right. When acceleration becomes zero, velocity is constant. So, v-t graph is a straight line parallel to the time-axis.

3. **(a) :**


$v_A = 30$ m/s, $v_B = 20$ m/s.

$v_B \times t = s$; $v_A \times t = s + 200$

$\therefore$ $t = 20$ sec.

4. **(a) :** $\vec{A} \times \vec{B} = 0 \Rightarrow \vec{A} \parallel \vec{B}$; $\vec{B} \times \vec{C} = 0 \Rightarrow \vec{B} \parallel \vec{C}$

$\therefore$ $\vec{A} \parallel \vec{C}$. So, $\vec{A} \times \vec{C} = 0$.

5. **(a) :** At all times, the horizontal component of the velocity of the bomb will be the same as the horizontal component of the velocity of the aeroplane. So, the horizontal displacements would remain the same at all times.

6. **(c) :** $T = \frac{2m_1m_2}{m_1+m_2}(2g)$ or, $T = \frac{2\frac{w_1}{g}\frac{w_2}{g}}{\frac{w_1}{g}+\frac{w_2}{g}}(2g)$

or, $T = \frac{2w_1w_2}{g^2} \times \frac{g}{w_1+w_2}(2g)$ or, $T = \frac{4w_1w_2}{w_1+w_2}$.

7. **(d) :** Water exerts an upward force on the finger [Archimede's principle]. According to Newton's third law of motion, the finger would exert equal and opposite force on water and hence on the bottom of the beaker. So, the reading of the spring balance would increase.

8. **(a) :** In the first case, $h = \frac{1}{2}gt_1^2$ ... (i)

In the second case, $h - vt_2 = -vt_2 + \frac{1}{2}gt_2^2$

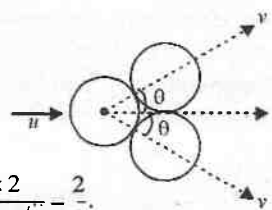
or, $h = \frac{1}{2}gt_2^2$ ... (ii)

Comparing (i) and (ii), $t_1 = t_2$.

9. **(a) :** $mu = 2mv\cos\theta$

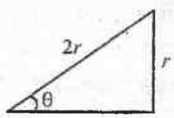
But $\theta = 30°$

$\therefore$ $u = 2v\cos 30° = \sqrt{3}v$

Using one ball for calculation,


$$e = \frac{v-0}{u\cos 30° - 0} = \frac{v \times 2}{\sqrt{3}v \times \sqrt{3}} = \frac{2}{3}.$$

$\sin\theta = \frac{r}{2r}$

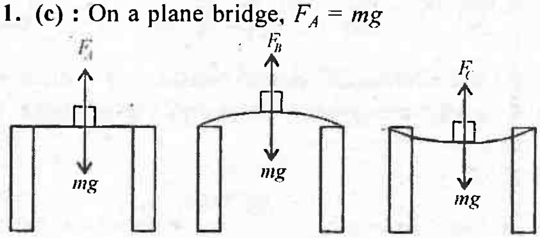
or, $\sin\theta = \frac{1}{2}$ or, $\theta = 30°$].


10. **(d) :** $E_k = \frac{p^2}{2m}$

p is increased by a factor of 3/2. So, E_k is increased by a factor of 9/4.

Percentage increase of kinetic energy

$$= \frac{\frac{9}{4}-1}{1} \times 100 = \frac{5}{4} \times 100 = 125.$$

11. **(c) :** On a plane bridge, $F_A = mg$


On convex bridge, $mg - F_B = \frac{mv^2}{R}$

or, $F_B = mg - \frac{mv^2}{R}$

On a concave bridge, $F_C - mg = \frac{mv^2}{R}$

or, $F_C - mg + \frac{mv^2}{R}$

Clearly, F_C is maximum of the three forces.

12. (a) : Accoding to Kepler's third law,

$T^2 \propto r^3$ or, $T \propto r^{3/2}$

$\omega = \frac{2\pi}{T}$ or, $\omega \propto r^{-3/2}$

Now, $L = mr^2\omega$ or, $L \propto r^{2-3/2}$ or, $L \propto r^{1/2}$.

13. (d) : Moments of inertia of rings I and II about

$YY' = 2\times\frac{3}{2}MR^2 = 3MR^2$

Moment of inertia of ring III about $YY' = \frac{1}{2}MR^2$

Total moment of inertia = $3MR^2 + \frac{1}{2}MR^2 = \frac{7}{2}MR^2$.

14. (c) : $g = \frac{4}{3}\pi G\rho R$. $\therefore$ $\frac{g_1}{g_2} = \frac{\rho_1 R_1}{\rho_2 R_2} = \frac{mx}{ny}$.

15. (a) : Let us first calculate the mass of inner solid sphere of radius r.

Mass of inner solid sphere,

$$M' = \frac{M_e}{\frac{4}{3}\pi R_e^3}\times\frac{4}{3}\pi r^3 = \frac{M_e r^3}{R_e^3}$$

Now, $g = \frac{GM_e r^3}{R_e^3}\times\frac{1}{r^2}$ or, $g = \frac{GM_e r}{R_e^3}$

Force on particle of mass m = $mg - \frac{GM_e mr}{R_e^3}$.

16. (b) : Tension is maximum when the stone is at the lowest point.

17. (b) : $Y = \frac{F}{\pi R^2}\times\frac{l}{\Delta l}$; F, l and Δl are constants.

$\therefore$ $R^2 \propto \frac{1}{Y}$ i.e. $\frac{R_S^2}{R_B^2} = \frac{Y_B}{Y_S} = \frac{10^{11}}{2\times10^{11}} = \frac{1}{2}$

or. $\frac{R_S}{R_B} = \frac{1}{\sqrt{2}}$ or, $R_S = \frac{R_B}{\sqrt{2}}$.

18. (c) : $\frac{2V}{3}\times 1\times g = mg$; $\frac{V}{4}\rho g = mg$

Comparing, $\frac{V}{4}\rho g = \frac{2V}{3}\times 1\times g$ or, $\rho = \frac{8}{3}\text{ gcm}^{-3}$

19. (a)

20. (c) : For a given pressure, V is small for T_1. Since $V \propto T$, therefore, $T_1 < T_2$.

21. (d) : $C_{r.m.s.} = \sqrt{\frac{3RT}{M}}$ or, $T \propto M$

$\therefore$ $\frac{T'}{T} = \frac{4}{2} = 2$ or, $T' = 2T$

or, $T' = 2 \times 273$ K = 546 K.

22. (b) : When A and B are mixed,

$mS_B(19 - 16) = mS_A(16 - 12)$

or, $3S_B = 4S_A$ ....(i)

When B and C are mixed,

$mS_B(23 - 19) = mS_C(28 - 23)$

or, $4S_B = 5S_C$ ... (ii)

When A and C are mixed,

$mS_A(T - 12) = mS_C(28 - T)$

or, $\frac{S_A}{S_C} = \frac{28 - T}{T - 12}$ ... (iii)

Dividing (i) by (ii),

$\frac{4S_A}{5S_C} = \frac{3S_B}{4S_B} = \frac{3}{4}$ or, $\frac{S_A}{S_C} = \frac{3}{4}\times\frac{5}{4} = \frac{15}{16}$

From eqn. (iii), $\frac{15}{16} = \frac{28 - T}{T - 12}$

$15T + 16T = 16 \times 28 + 15 \times 12$

or, $31T = 448 + 180 = 628$ or, $T = \frac{628}{31} = 20.3°$.

23. (a) : $540 \times 80 + 540 \times 1 \times (\theta - 0) = 540(80 - \theta)$

or, $80 + \theta = 80 - \theta$ or, $2\theta = 0$ or, $\theta = 0°C$

24. (b) : $\frac{KA(\theta - 0)}{l} = \frac{KA(90 - \theta)}{l} + \frac{KA(90 - \theta)}{l}$

or, $\theta = 2(90 - \theta)$

or, $3\theta = 180°$ or, $\theta = 180°/3 = 60°C$

25. (b) : Required time interval

$$\frac{1}{v_1 - v_2} = \frac{1}{258 - 256} = \frac{1}{2}\text{ s} = 0.5\text{ s}.$$

26. (b) : $y = \frac{4}{2}\left[2\cos^2\left(\frac{t}{2}\right)\right]\sin(1000t)$

or, $y = 2(1 + \cos t)\sin 1000t$

or, $y = 2\sin 1000t + 2\sin 1000t\cos t$

or, $y = 2\sin 1000t + \sin(1001t) + \sin(999t)$

So, the given expression is a result of the superposition of three independent harmonic motions.

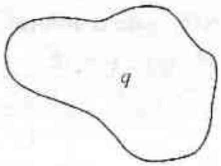
27. (a) : $g' = g + \frac{g}{4} = \frac{5g}{4}$

$$T' = 2\pi\sqrt{\frac{4l}{5g}} \quad \text{or,} \quad T' = \frac{2}{\sqrt{5}}2\pi\sqrt{\frac{l}{g}} \quad \text{or,} \quad T' = \frac{2}{\sqrt{5}}T.$$

28. (a) : $W = \oint_C \vec{E}\cdot d\vec{r} = 0$

For in this case, $\vec{E} \perp d\vec{r}$.

29. (b) : From Gauss's theorem, the flux of electrostatic field due to a charge of q coulomb is



$$\phi = \oint_S \vec{E}\cdot d\vec{S} = \frac{q}{\varepsilon_0}$$

For q = 1 coulomb, $\phi = 1/\varepsilon_0$.

30. (a) : Electric field (E) = V/d.
Since V is constant and d is increasing, thus E decreases. Now C is also decreasing and therefore charge content decreases.

31. (a) : We have $C_1 = \frac{K_1 A\varepsilon_0}{t_1}$; $\frac{1}{C_1} = \frac{t_1}{K_1 A\varepsilon_0}$

$$C_2 = \frac{K_2 A\varepsilon_0}{t_2}; \quad \frac{1}{C_2} = \frac{t_2}{K_2 A\varepsilon_0}$$

$$C_3 = \frac{K_3 A\varepsilon_0}{t_3}; \quad \frac{1}{C_3} = \frac{t_3}{K_3 A\varepsilon_0}$$

The effective capacitance (C) is given by

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} = \left(\frac{t_1}{K_1} + \frac{t_2}{K_2} + \frac{t_3}{K_3}\right)\frac{1}{A\varepsilon_0}$$

or, $$C = \frac{\varepsilon_0 A}{\left(\frac{t_1}{K_1} + \frac{t_2}{K_2} + \frac{t_3}{K_3}\right)}.$$

32. (c) : $\rho = \frac{RA}{l} = \frac{A}{Gl} = \frac{8.00\times10^{-5}}{2.45\times8.00} = 4.1\times10^{-7}$ S.

33. (c) : Total resistance of the part AB is $R_{AB} = 2 + 2 + 2 = 6\ \Omega$.

The current is $i = \frac{E}{9+6} = \frac{E}{15}$ A

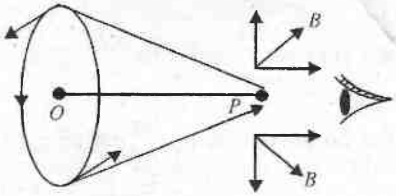
The potential difference between A and B is

$$V_{AB} = \frac{(1/3)}{15}\times 6 \text{ volt} = \frac{2}{15} \text{ volt.}$$

34. (b) : The resultant resistance in parallel is $\lambda = R/n$. On connecting them in series we have the resultant resistance $R_s = nR = n^2\lambda$.

35. (d) : Ohm's law is not applicable in valves, semiconductors, electrolytes, transistors etc.

36. (d) : We have taken two diametrically opposite segments. The fields due to these two segments at the point P are indicated in the figure. The vertical components cancel each other and horizontal components get added. So, the field will be along the axis away from the centre O.



37. (a) : $\vec{B} = \frac{-\mu_0}{4\pi}\frac{(3\pi/2)I\hat{k}}{r} = -10^{-7}\times\frac{3\pi\times100\times60\hat{k}}{2\times2}$

$$= -45\pi\times10^{-5}\hat{k} \text{ tesla.}$$

38. (c)

39. (b) : A proton moving with a constant velocity passes through a region without any change in velocity. So a magnetic field $(\vec{B})$ either may not be present or, if present, then it is in the direction of the velocity. The electric field $(\vec{E})$ is definitely zero.

40. (a) : E_X, B_Y are perpendicular to each other and both of them are normal to Z-axis.

41. (c) : Here L_2 = 0.5 H and L_3 = 0.5 H are in parallel.

$$\therefore \quad L' = \frac{L_2 L_3}{L_2 + L_3} = \frac{0.5}{2} = 0.25 \text{ H}$$

Now, L_1 and L' are in series.

$\therefore \quad L_{equ.} = L_1 + L' = 1.75 + 0.25 = 2.00$ H.

42. (c)

43. (d) : Here R = 150 Ω, L = 1.0 henry

$$\upsilon = \frac{150}{2\pi} \text{ Hz}, \phi = ?$$

$$\tan\phi = \frac{\omega L}{R} = \frac{2\pi\upsilon L}{R} = 2\pi\times\frac{150}{2\pi}\times\frac{1}{150} = 1$$

$\therefore \quad \phi = 45° = \pi/4$.

44. (b) : For a point source, $I \propto 1/r^2$

and $A \propto \sqrt{I}$. $\therefore \quad A \propto \sqrt{\frac{1}{r^2}}$ or, $A \propto \frac{1}{r}$.

45. (c) : As a constant path difference is introduced in the rays coming from two slits.

46. (d) : Independent waves can't be coherent and can't produce interference.

47. (c) : As $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{F_2}\right)$

For no deviation, $d\left(\frac{1}{f}\right) = d(\mu)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] = 0$

$\Rightarrow \frac{1}{R_1} = \frac{1}{R_2} \Rightarrow R_1 = R_2.$

48. (b) : Since $E = \frac{I}{r^2}$

or, $I = Er^2 = 25 \times (2)^2 = 100$ candela.

49. (b) : $P_1 = 6$ D, $P_2 = -4$ D

$\Rightarrow P = P_1 + P_2 = (6 - 4)$ D $= 2$ D.

$\therefore f = +50$ cm, convex lens.

50. (c) : In normal adjustment, $L = f_o + f_e$

and $M = \frac{f_o}{f_e}$ or, $10 = \frac{f_o}{f_e} \Rightarrow f_o = 50$ cm.

$\therefore L = 5$ cm $+ 50$ cm $= 55$ cm.

51. (c) : Since work function of aluminium is greater than the energy of photons.

52. (a) : $\lambda = \frac{h}{mv}$ or, $\lambda = \frac{h}{\sqrt{2meV}}$ or, $\lambda \propto \frac{1}{\sqrt{m}}$

$\lambda_\alpha \propto \frac{1}{\sqrt{m_\alpha}}, \quad \lambda_p \propto \frac{1}{\sqrt{m_p}}$

$\therefore \frac{\lambda_p}{\lambda_\alpha} = \left(\frac{m_\alpha}{m_p}\right)^{1/2} = \left(\frac{4}{1}\right)^{1/2} = 2.$

53. (b) : Use $T_{1/2} = \frac{0.693}{1.07 \times 10^{-4}}$.

54. (c) : $E = P \times t = 10^6 \times 1 = 10^6$ J

Energy released per fission = 200 MeV

$= 200 \times 10^6 \times 1.6 \times 10^{-19}$ J

$= 3.2 \times 10^{-11}$ J.

$\therefore$ Number of fission needed per second

$= \frac{10^6}{3.2 \times 10^{-11}} = 3.125 \times 10^{16}$

Number of fission needed in one year

$= 3.125 \times 10^{16} \times 365 \times 24 \times 60 \times 60$

$\approx 9.855 \times 10^{23}$.

$\therefore$ Number of nucleus involved/fission

$= 9.855 \times 10^{23}$

$\therefore$ Mass required $= \frac{235}{6.02 \times 10^{23}} \times 9.855 \times 10^{23}$

≈ 384 g.

55. (a) : Current gain, $\alpha = \frac{\Delta I_C}{\Delta I_E}$.

56. (d)

57. (b) : When two input of NAND gate are combined NOT gate is formed.

58. (c) : $V = IR$

$\therefore R = \frac{V}{I} = \frac{0.9}{55 \times 10^3}$ ohm $= \frac{9}{550} \times 10^3$ ohm

≈ 16.4 ohm.

59. (d) : Since $I_e = I_b + I_c$

$\therefore I_e - I_b = I_c$

and since $I_c = 90\% I_e = 0.9 I_e$

$\therefore \frac{I_c}{I_e} = 0.9 = \frac{9}{10}$

$\Rightarrow$ If $I_c = 9$ mA, $I_e = 10$ mA.

So, $I_b = I_e - I_c = (10 - 9)$ mA $= 1$ mA.

60. (c) : $d = \sqrt{2hR} = \sqrt{2 \times 240 \times 6.4 \times 10^6}$

$= 55.4 \times 10^3$ m ≈ 55 km.

Practice Problems *for*

IIT-JEE 2006

Exam on 9th April 2006

(Based on New Pattern)

Time : 2 hrs **Max. Marks : 150**

- This paper consists of 50 questions having only one correct answer (including some questions based on short passages).
- Corresponding to right answer there will be +3 marks & for incorrect/wrong answer there will be –1 mark.

1. The measurement of radius, length and resistance of a metal wire of circular cross section are radius = (0.26 ± 0.02) cm ; length = $(156.0 \pm 0.064\%)$ cm and resistance = $(64 \pm 2)\Omega$. The maximum error in measurement of specific resistance of the material of the wire is

(a) 18.6% (b) 8.6% (c) 17% (d) 12%.

2. The Young's modulus of brass and steel are respectively 10×10^{10} N/m^2 and 2×10^{10} N/m^2. A brass wire and a steel wire of the same length are extended by 1 mm under the same force, the radii of brass and steel wires are R_B and R_S respectively. Then

(a) $R_S = \sqrt{2}R_B$ (b) $R_S = R_B/\sqrt{2}$

(c) $R_S = 4R_B$ (d) $R_S = R_B/4$

3. Two satellites of masses m_1 and $m_2 (m_1 > m_2)$ are revolving round the earth in circular orbits of radii r_1 and r_2 $(r_1 > r_2)$ respectively. Which of the following statements is true regarding their speeds v_1 and v_2 ?

(a) $v_1 = v_2$ (b) $v_1 > v_2$

(c) $v_1 < v_2$ (d) $v_1/r_1 = v_2/r_2$

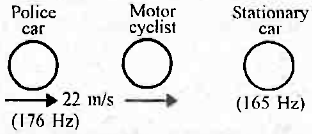
4. A horizontal pipe line carries water in a stream line flow. At a point along the pipe where the cross-sectional area is 10 cm^{-2}, the water velocity is 1 m/s and the pressure is 2000 Pa. The pressure of water at another point where the cross-sectional area is 5 cm^2, is

(a) 500 Pa (b) 50 Pa

(c) 5 Pa (d) 5×10^3 Pa.

(Density of water = 10^3 kg. m^{-3})

5. A police car moving with velocity 22 m/s and emitting sound of frequency 176 Hz follows a motor cyclist which in turn is moving towards a stationary car and away from the police car as shown in figure. The stationary car is emitting a sound of frequency 165 Hz. If motor cyclist does not hear any beat, then his velocity is



(a) 11 m/s (b) 22 m/s (c) 33 m/s (d) 44 m/s

6. The velocity of sound in an ideal gas at temperature T_1 and T_2 K are found to be V_1 and V_2 respectively. If the root mean square speed of the same gas at the same temperature T_1 and T_2 are v_1 and v_2 respectively , then

(a) $v_2 = v_1(V_2/V_1)$ (b) $v_2 = v_1(V_1/V_2)$

(c) $v_2 = v_1\sqrt{(V_2/V_1)}$ (d) $v_2 = v_1\sqrt{(V_1/V_2)}$.

7. The superposition of two harmonic oscillations in the same direction results in the oscillation of a point according to the equation $x = a\cos 2.1t \cos 50t$, where t is in second. Find the period in which they beat

(a) 1 second (b) 1.497 second

(c) 2.1 second (d) 2.994 second.

8. A sonometer wire resonates with a given tuning fork forming standing waves with five antinodes between the two bridges when a mass of 9 kg is suspended from the wire. When this mass is replaced by a mass M, the wire resonates with the same tuning fork forming three antinodes for the same positions of the bridges. The value of m is

Contributed by Deptt. of Physics, **Momentum**, Jabalpur (M.P). Ph.: (0761)5005358

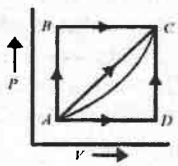
(a) 25 kg (b) 5 kg (c) 12.5 kg (d) 1/25 kg.

9. A thin copper wire of length L increases in length by 1% when heated from temperature T_1 to T_2. What is the percentage change in area when a thin copper plate having dimensions $2L \times L$ is heated from T_1 to T_2 ?
(a) 1% (b) 3% (c) 2% (d) 4%.

10. Two litre of water at initial temperature of 27°C is heated by a heater of power 1 kW in a kettle. If the lid of the kettle is open, then heat energy is lost at a constant rate of 160 J/s. The time in which the temperature will rise from 27°C to 77°C is
(specific heat of water = 4.2 kJ/kg)
(a) 5 min. 20 sec. (b) 8 min. 20 sec.
(c) 10 min. 40 sec. (d) 12 min. 50 sec.

11. The average translation kinetic energy of a molecule in gas becomes equal to 1 eV at a temperature
(a) 7733 K (b) 8833 K
(c) 3377 K (d) 3388 K.

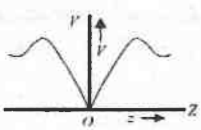
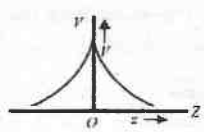
12. A thermodynamical process is shown in the figure.The presures and volumes corresponding to some points in the figure are
$P_A = 3 \times 10^4$ Pa, $V_A = 2 \times 10^{-3}$ m^3
$P_F = 8 \times 10^4$ Pa, $V_D = 5 \times 10^{-3}$ m^3

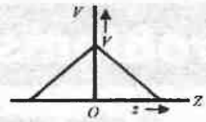
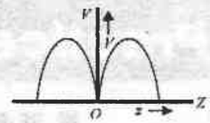


In the process AB, 600 J of heat is added to the system and in process BC 200 J of heat is added to the system. The change in internal energy of the system in process AC would be
(a) 560 J (b) 800 J (c) 600 J (d) 640 J

13. Three discs A, B and C having radii 2 m, 4 m and 6 m respectively are coated with carbon black on their outer surfaces. The wavelengths corresponding to maximum intensity are 300 nm, 400 nm, respectively. The power radiated by them are Q_A, Q_B and Q_C respectively.
(a) Q_A is maximum (b) Q_B is maximum
(c) Q_C is maximum (d) $Q_A = Q_B = Q_C$

14. A circular ring carries a uniformly distributed positive charge and lies in X-Y plane with centre at origin of co-ordinate system. If at a point (0, 0, z) the potential is V, then which of the graph is correct ?

(a)  (b) 

(c)  (d) 

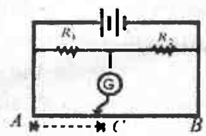
15. A fully charged capacitor has a capacitane C. It is discharged through a small coil of resistance wire embedded in a thermally insulated block of specific heat capacity s and mass m. If the temperature of the block is raised by ΔT, the potential difference V across the capacitor is

(a) $\dfrac{ms\Delta T}{C}$ (b) $\sqrt{\left[\dfrac{2ms\Delta T}{C}\right]}$

(c) $\sqrt{\left[\dfrac{2mC\Delta T}{s}\right]}$ (d) $\dfrac{mC\Delta T}{s}$

16. A capacitor of capacity C = 4.0 μF is connected through a resistance R = 2.5 MΩ across a battery of negligible internal resistance of 12 volt. The time after which the potential difference across the capacitor becomes three times to that of resistor is
(Given $\log_e 2 = 0.693$)
(a) 13.86 sec (b) 6.48 sec
(c) 3.24 sec (d) 20.52 sec

17. In the given circuit of figure no current is passing through the galvanometer connected to a meter bridge. Distance ACcorresponding to null deflection of galvanometer is x. What would be its value if the radius of the wire AB is doubled?



(a) $x/2$ (b) $2x$
(c) x (d) none of these

18. A galvanometer with resistance 100 Ω is converted into an ammeter with a resistance of 0.1 Ω. The galvanometer shows full scale deflection with current of 100 μA. Then the minimum current in the circuit for full scale deflection of galvanometer will be.
(a) 100.1 mA (b) 1000.1 mA
(c) 1.001 mA (d) 0.1001 mA

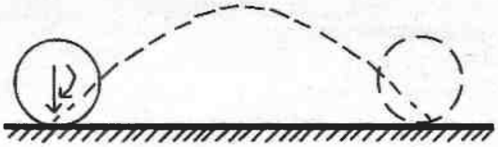
19. An electron of mass m_e, initially at rest, moves through a certain distance in a uniform electric field in time t_1. A proton of mass m_p, also, initially at rest, takes time t_2 to move through an equal distance in this uniform electric field. Neglecting the effect of gravity, the ratio of t_2/t_1 is nearly equal to

(a) 1 (b) $(m_p/m_e)^{1/2}$

(c) $(m_e/m_p)^{1/2}$ (d) 1836

Q .20 to 23. are based on this passage:

In an experiment, a spinning ball is made to fall on rough horizontal surface. While hitting the surface the ball has a velocity v_0 and angular velocity $\frac{5}{2}\frac{v_0}{R}$. After hitting the surface at A, the ball moves on the path shown and hits the surface again at B. This experiment is repeated for many surfaces of varying roughness. For a certain surface X the ball covers the maximum distance AB. Assume that all the surfaces used in the experiment are perfectly elastic and the ball is a uniform sphere of mass m, radius R.



20. The coefficient of friction between the surface X and the ball is

(a) 0.5 (b) 0.25 (c) 0.75 (d) 1.0

21. The magnitude of impulse imparted by surface X to the ball during the collision at A is

(a) mv_0 (b) $2\,mv_0$ (c) $\sqrt{5}\,mv_0$ (d) $\sqrt{3}\,mv_0$

22 Angular velocity of the ball just after collision at A is

(a) v_0/R (b) $v_0/2R$ (c) $2v_0/R$ (d) zero

23. Work done by the surface X on the ball during collision at A is

(a) $\frac{mv_0^2}{4}$ (b) $-\frac{5}{4}mv_0^2$ (c) $-\frac{mv_0^2}{4}$ (d) $\frac{5}{4}mv_0^2$

Q. 24 to 26. are based on this passage:

A block of mass 2 kg is placed on a rough incline whose angle of inclination (θ) can be varied. It is found that when $\theta = \tan^{-1}(1/2)$ the block just beings to slip. The angle of inclination of the incline is doubled and it is found that to keep the block stationary a minimum horizontal force F_{min} needs to be applied on the block, pressing it against the incline. The horizontal force is increased gradually and it is found that the block still does not move. When the applied force exceeds a value F_{max} the block begins to slide [$g = 10$ m/s^2]

24. The coefficient of friction between the block and the incline surface is

(a) 1/2 (b) 3/4 (c) 1/4 (d) zero

25. F_{min} is equal to

(a) 5 N (b) 20 N (c) 15 N (d) 10 N

26. When the applied force is $2F_{max}$, acceleration of the block is

(a) up the incline (b) down the incline

(c) zero (d) none of these

27. In Young's double slit experiment, the two slits act as coherent sources of equal amplitude A and of wavelength λ. In another experiment with the same set up, the two slits are sources of equal amplitude A and wavelength λ but are incoherent. The ratio of the intensity of light at the midpoint of the screen in the first case to that in the second case is

(a) 1 : 1 (b) 1 : 2 (c) 2 : 1 (d) $\sqrt{2}$: 1

28. A thin prism P_1 with angle 4° and made from glass of refractive index 1.54 is combined with another thin prism P_2 made from glass of refractive index 1.72 to produce dispersion without deviation. The angle of prism P_2 is

(a) 5.33° (b) 4° (c) 3° (d) 2.6°

29. A concave lens of glass, refractive index 1.5, has both surfaces of same radius of curvature R. On immersion in a medium of refractive index 1.75, it will behave as a

(a) convergent lens of focal length $3.5R$

(b) convergent lens of focal length $3.0R$

(c) divergent lens of focal length $3.5R$

(d) divergent lens of focal length $3.0R$

30. A ray of light travels from a denser to a rarer medium. The critical angle for two media is C. The maximum possible deviation of the ray will be

(a) $(\pi - C)$ (b) $(\pi/2 + C)$

(c) $2C$ (d) $(\pi - 2C)$

31. In an ideal double slit experiment, when a glass plate (refractive index 1.5) of thickness t is introduced in the path of one of the interfering beams (wavelength λ), the intensity at the position where the central maximum occured previously remains unchanged. The minimum thickness of the glass-plate is

(a) 2λ (b) $2\lambda/3$ (c) $\lambda/3$ (d) λ

32. The binding energy per nucleon of deuteron ($_1H^2$) and helium nucleus ($_2He^4$) is 1.1 MeV and 7 MeV respectively. If two deuteron nuclei react to form a single helium nucleus, then energy released is

(a) 13.9 MeV (b) 26.9 MeV
(c) 25.8 MeV (d) 19.2 MeV

33. Two radioactive substances X and Y initially contain equal number of nuclei. X has a half life of 1 hour and Y has half life of 2 hours. After two hours the ratio of the activity of X to the activity of Y is

(a) 1 : 4 (b) 1: 2 (c) 1 : 1 (d) 2 : 1

34. Imagine an atom made up of a proton and a hypothetical particle of double the mass of the electron but having the same charge as tne electron. Apply the Bohr atom model and consider all possible transitions of this hypothetical particle to the first excited level. The longest wavelength photon that will be emitted has wavelength λ(given in terms of the Rydberg constant R for the hydrogen atom) equal to

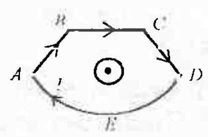
(a) $9/(5R)$ (b) $36/(5R)$
(c) $18/(5R)$ (d) $4/R$

35. Electrons with energy 80 keV are incident on the tungsten target of an X-ray tube. K shell electrons of tungsten have –72.5 keV energy. X-rays emitted by the tube contain only

(a) a continuous X-ray spectrum (Bremsstrahlung) with all wavelengths of -0.155Å
(b) a continuous X-ray spectrum (Bremsstrahlung) with all wavelengths
(c) the characteristic X-ray spectrum of tungsten
(d) a continuous X-ray spectrum (Bremsstrahlung) with a minimum wavelength of – 0.155 Å and the characteristic X-ray spectrum of tungsten.

Q. 36 to 37 are based on this passage:

In the closed circuit shown, AB, BC and CD are straight conductors, each of length R and DEA is a semi circle of radius R. A small circles loops of radius r is coplanar with the circuit and the centre of loop coincides with centre of curvature of the semicircle. The current through the circuit increases at a constant rate $dI/dt = \alpha$.



36. The magnetic field at centre of the loop as function of I is

(a) $\frac{\mu_0 I}{4\pi R}(\pi+\sqrt{3})$ (b) $\frac{\mu_0 I}{4\pi R}(\pi+2\sqrt{3})$

(c) $\frac{\mu_0 I}{2\pi R}(\pi+\sqrt{3})$ (d) $\frac{\mu_0 I}{4\pi R}(2\pi+3\sqrt{3})$

37. Since loop is small, assume that the field at its centre is approximately the field at all points inside it. The magnitude of induced emf in the loop

(a) $\frac{\mu_0(\pi+2\sqrt{3})r^2\alpha}{4R}$ (b) $\frac{\mu_0(\pi+\sqrt{3})r^2\alpha}{4R}$

(c) $\frac{\mu_0(2\pi+\sqrt{3})r^2\alpha}{2R}$ (d) $\frac{\mu_0(\pi+2\sqrt{3})}{2R}r^2\alpha$

Q. 38 to 39 are based on this passage:

A radio nuclide consists of two isotopes. One of the isotopes decays by α-emission and the other by β-emission with half lives $T_1 = 405$ sec and $T_2 = 1620$ s respectively. At $t = 0$, probabilities of getting α and β-particles from the radio nuclide are equal.

38. The probability of getting α particle from the radio nuclide at $t = 1620$ sec is

(a) 1/9 (b) 8/9 (c) 2/3 (d) 3/8

39. The ratio of number of nuclei of α emitter and β-emitter at time $t = 0$ is

(a) 1/3 (b) 1/2 (c) 1/4 (d) 2/5

Q. 40 to 42 are based on this passage:

A vertical cylindrical vessel of area $A = 15$ cm^2 contain $n = 0.01$ mole of each of He, O_2 and CO_2. At the lower end, the cylinder has a flexible diaphragm and at the other end a fixed piston. Height of the gas column is $h = 30$ cm and its 1st and 3rd overtone frequencies are 900 Hz and 2100 Hz respectively

40. The speed of sound in the gas mixture is

(a) 330 m/s (b) 300 m/s
(c) 280 m/s (d) 360 m/s

41. The ratio of specific heats (γ) for the mixture is

(a) 10/7 (b) 5/7 (c) 13/7 (d) 11/7

42. Temperature of the gas in the cylinder is

(a) 191.47 K (b) 291.47 K
(c) 391.47 K (d) 0 K

Q. 43 to 45 are based on this passage:

RMS velocity of molecules of a di-atomic gas is to be increased to 1.5 times. In process A it is done adiabatically

and in process B it is done isobarically. The value of γ for gas = 1.4 given $(1.5)^5 = 7.6$

43. The ratio of initial and final volume for process A is

(a) 7.6 (b) $(7.6)^2$ (c) $(7.6)^{2.5}$ (d) $(7.6)^{1.5}$

44. The ratio of initial and final volume for process B is

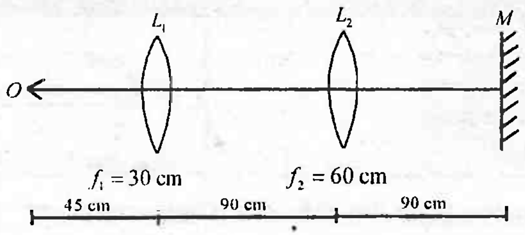
(a) $\frac{2}{5}$ (b) $\frac{1}{9}$ (c) $\frac{4}{9}$ (d) $\frac{7}{9}$

45. The ratio of work done by the gas during A and B is

(a) −2.5 (b) 2.5 (c) −1.5 (d) 1.5

Q. 46 to 47 are based on this passage:

Two thin convex lenses L_1 and L_2 having focal length f_1 = 30 cm and f_2 = 60 cm respectively are placed co-axially as shown . A plane mirror is placed normal to the axis and a point luminous object O on the axis as shown. Light rays emitted by O first pass through lenses L_1 and L_2 respectively and then reflect from mirror M and then reflected rays pass through L_2 and L_1 respectively.



46. The image formed by mirror M is at a distance of

(a) 180 cm from L_2 (b) 90 cm from L_2
(c) 180 cm from mirror (d) 120 cm from mirror

47. The final image is formed at

(a) pole of L_1 (b) between L_1 and L_2
(c) to the right of O (d) between O and L_1

Q. 48 to 50 are based on this passage:

A small sphere is charged uniformly and placed at point $A(x_1, y_1)$ so that at point B (8, 7) electric field strength is $E = (54\hat{i} + 72\hat{j})$ N/C and potential is +900 volt

48. The charge on sphere is

(a) 0.5 μC (b) 0.4 μC
(c) 0.8 μC (d) 1 μC

49. Co-ordinates of point A are

(a) (2, −1) (b) (2, 1)
(c) (3, −1) (d) (3, 1)

50. If dielectric strength of air is 3×10^6 V/m, minimum possible radius of the sphere is

(a) $\sqrt{20}$ cm (b) $\sqrt{10}$ cm
(c) $\sqrt{30}$ cm (d) 2 cm

ANSWERS

1. (a)	2. (b)	3. (c)	4. (a)	5. (b)
6. (a)	7. (b)	8. (a)	9. (d)	10. (b)
11. (a)	12. (a)	13. (b)	14. (b)	15. (b)
16. (a)	17. (c)	18. (a)	19. (b)	20. (a)
21. (c)	22. (d)	23. (b)	24. (a)	25. (d)
26. (a)	27. (c)	28. (c)	29. (a)	30. (d)
31. (a)	32. (c)	33. (c)	34. (c)	35. (d)
36. (b)	37. (a)	38. (a)	39. (c)	40. (d)
41. (a)	42. (b)	43. (a)	44. (c)	45. (a)
46. (a)	47. (a)	48. (d)	49. (a)	50. (c)

Exam Alert

- CBSE (Pre) - 2nd April
- IIT-JEE - 9th April
- MGIMS - 16th April
- Vellore (Engg.) - 16th April
- WB - JEE - 22nd & 23rd April
- UPSEE - 23rd April
- UGET (Mahe) - 23rd April
- Kerala (PET) - 24th & 25th April
- Kerala (PMT) - 26th & 27th April
- BVP (Medical) - 29th April
- AIEEE - 30th April
- AMU (Engg.) - 4th May
- AFMC - 7th May
- BHU (Screening) - 10th May
- AMU (Medical) - 11th May
- CBSE (Mains) - 14th May
- BVP (Engg.) - 21st May
- Orissa JEE - 21st May
- UPCPMT - 21st May
- AIIMS - 1st June
- BHU (Mains) - 18th June

Exam on 2^{nd} April 2006

Practice Paper *for*

CBSE-PMT (Prelims) - 2006

1. The dimensions of $[\mu_0\varepsilon_0]^{-1/2}$ are the same as that of
(a) time period (b) wavelength
(c) frequency (d) velocity.

2. A car accelerates from rest at a constant rate of $2\ ms^{-2}$ for sometime. Then, it retards at constant rate of $4\ ms^{-2}$ and comes to rest. If the total time for which it remains in motion in 3 seconds, what is the total distance travelled?
(a) 2 m (b) 3 m (c) 4 m (d) 6 m.

3. A projectile can have the same range R for two angles of projection. If t_1 and t_2 be the times of flight in the two cases then what is the product of the two times of flight?
(a) $t_1t_2 \propto R^2$ (b) $t_1t_2 \propto R$
(c) $t_1t_2 \propto \frac{1}{R}$ (d) $t_1t_2 \propto \frac{1}{R^2}$.

4. An automobile is turning around a circular road of radius r. The coefficient of friction between the tyres and the road is μ. The velocity of the vehicle should not be more than
(a) μrg (b) $\mu g/r$ (c) $\sqrt{\mu g/r}$ (d) $\sqrt{\mu rg}$

5. A monkey of mass 20 kg is holding a vertical rope. The rope can break when a mass of 25 kg is suspended from it. What is the maximum acceleration with which the monkey can climb up along the rope?
(a) $2.5\ m/s^2$ (b) $5\ m/s^2$
(c) $7\ m/s^2$ (d) $10\ m/s^2$.

6. An engine pumps up 100 kg of water through a height of 10 m in 5 seconds. Given that the efficiency of engine is 60%, what is the power of the engine? (Take $g = 10\ m/s^2$).
(a) 33 kW (b) 3.3 kW
(c) 0.33 kW (d) 0.033 kW.

7. A neutron is moving with a velocity u. It collides head on and elastically with an atom of mass number A. If the initial kinetic energy of the neutron is E, how much kinetic energy is retained by neutron after collision?
(a) $\left[\frac{A}{(A+1)}\right]^2 E$ (b) $\left[\frac{A}{(A+1)^2}\right] E$
(c) $\left[\frac{A-1}{A+1}\right]^2 E$ (d) $\left[\frac{A-1}{(A+1)^2}\right]^2 E$

8. Three identical particles each of mass 1 kg are placed touching each other with their centres on a straight line. Their centres are marked A, B and C respectively. The distance of centre of mass of the system from A is
(a) $\frac{AB+AC+BC}{3}$ (b) $\frac{AB+AC}{3}$
(c) $\frac{AB+BC}{3}$ (d) $\frac{AC+BC}{3}$.

9. Suppose g_e be the acceleration due to gravity at the equator and g_p be that at poles. Assuming the earth to be a sphere of radius R_e rotating about its own axis with angular speed ω, then $g_p - g_e$ is given by
(a) ω^2/R_e (b) $R_e\omega^2$ (c) ωR_e (d) ω^2/R_e^2.

10. A pendulum is suspended from the ceiling of the compartment of a train. When the train is stationary, the time period of the pendulum is T. If the train accelerates, the time period of pendulum
(a) will increase (b) will decrease
(c) will remain unchanged
(d) the pendulum will not oscillate.

11. A simple pendulum performs simple harmonic motion about $x = 0$ with an amplitude A and time period T. The speed of the pendulum at $x = A/2$ will be
(a) $\frac{\pi A\sqrt{3}}{T}$ (b) $\frac{\pi A}{T}$
(c) $\frac{\pi A\sqrt{3}}{2T}$ (d) $\frac{3\pi A^2}{T}$

12. Two rods of different materials having coefficient

of linear expansion α_1, α_2 and Young's modulii Y_1, Y_2 respectively are fixed between two rigid massive walls. The rods are heated such that they undergo the same increase in temperature. There is no bending of rods. If $\alpha_1 : \alpha_2 = 2 : 3$, the thermal stress developed in the two rods are equal provided $Y_1 : Y_2$ is equal to
(a) 2 : 3 (b) 1 : 1 (c) 3 : 2 (d) 4 : 9.

13. A wooden cube floats just inside tne water, when a mass of 300 g is placed on it. If the mass is removed, the cube floats 3 cm above the water surface. The length of the side of cube is
(a) 10 cm (b) 15 cm (c) 20 cm (d) 30 cm.

14. The quantity which is zero on an average for the molecules of an ideal gas is
(a) momentum (b) density
(c) kinetic energy (d) speed.

15. The speed of sound in a gas is v. The rms velocity of gas molecules is C. The ratio of v to C is
(a) $3/\gamma$ (b) $\gamma/3$ (c) $\sqrt{3/\gamma}$ (d) $\sqrt{\gamma/3}$

16. Two factories are sounding their sirens at 800 Hz. A man goes from one factory to the other at a speed of 2 ms^{-1}. The velocity of sound is 320 ms^{-1}. The number of beats heard by the person in one second will be
(a) 2 (b) 4 (c) 8 (d) 10.

17. A liquid having coefficient of cubical expansion γ is filled in the container having coefficient of linear expansion as α. If, on heating, the liquid overflows, then which of the following relations is correct?
(a) $\gamma = 2\sigma$ (b) $\gamma < 3\alpha$
(c) $\gamma > 3\alpha$ (d) $2\gamma = 3\alpha$.

18. The first law of thermodynamics forbids flow of a heat
(a) from low temperature to higher temperature
(b) from lower pressure to higher pressure
(c) from bodies with more heat content to one with less heat content
(d) none of the above cases.

19. When the temperature difference between the source and the sink increases, the efficiency of the heat engine
(a) increases (b) decreases
(c) is not affected
(d) may increase or decrease depending upon the nature of the working substances.

20. A slab consists of two parallel layers of two different materials of same thickness having thermal conductivities K_1 and K_2. The equivalent thermal conductivity of the slab is
(a) $K_1 + K_2$ (b) $\frac{K_1 + K_2}{2}$
(c) $\frac{K_1 + K_2}{K_1K_2}$ (d) $\frac{2K_1K_2}{K_1 + K_2}$

21. A man runs towards the plane mirror at 2 ms^{-1}. The relative speed of his image with respect to him will be
(a) 2 ms^{-1} (b) 4 ms^{-1} (c) 8 ms^{-1} (d) 10 ms^{-1}.

22. We wish to make a plano convex lens of focal length 16 cm from glass having refractive index 1.5. It is to be used in air. What should be the radius of curvature of the curved surface?
(a) 8 cm (b) 12 cm (c) 16 cm (d) 24 cm.

23. We have a right angles isosceles prism. Its refractive index is 1.5. If we incident ray normally on one of the two perpendicular surfaces, which of the following phenomenon will take place?
(a) dispersion (b) total internal reflection
(c) refraction (d) none of these.

24. Two coherent monochromatic light beams of intensities I and $4I$ are superposed. The maximum and minimum possible intensities in the resulting beam are
(a) $5I$ and I (b) $5I$ and $3I$
(c) $9I$ and I (d) $9I$ and $3I$.

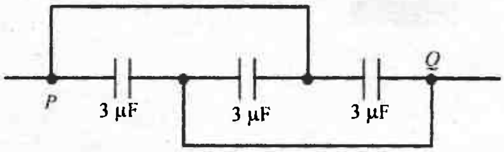
25. A charged isolated metal sphere of radius r carries a fixed charge. A small charge is placed at a distance s from its surface. It experiences a force which is
(a) proportional to r (b) proportional to $(r + s)$
(c) inversely proportional to $(r + s)^2$
(d) inversely proportional to s^2.

26. Two equal metal balls are charged to 10 and –20 units of electricity. Then they are brought in contact with each other and then again separated to the original distance. The ratio of forces between the two balls is
(a) – 8 : 1 (b) 1 : 8 (c) +2 : 1 (d) 1 : 2.

27. At a point in space, the electric field points towards north. In the region, surrounding this point, the rate of change of potential will be zero along the
(a) north (b) south
(c) north-south (d) east-west.

28. From a supply of identical capacitors rated 8 μF, 250 V the minimum number required to form a composite 16 μF 1000 V capacitor is
(a) 2 (b) 4 (c) 8 (d) 32.

29. Find the effective capacitance between points P and Q. It will be equal to

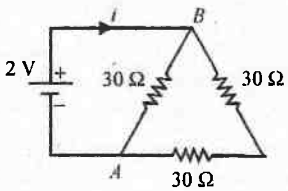


(a) 9 μF (b) 4.5 μF (c) 1 μF (d) 6 μF.

30. A piece of copper and another of germanium are cooled from room temperature to 80° K. The resistance of
(a) each of them increases
(b) each of them decreases
(c) copper increases and germanium decreases
(d) copper decreases and germanium increases.

31. Two bulbs take 50 watts each when connected in parallel to 100 V source. The total power consumed by them when they are connected in series with the same source is
(a) 100 W (b) 75 W (c) 50 W (d) 25 W.

32. The current i in the circuit as shown in the figure is
(a) 1/45 amp.
(b) 1/15 amp.
(c) 1/10 amp.
(d) 1/5 amp.



33. In a potentiometer, the length and resistance of the wire are 10 metre and 20 Ω respectively. The wire is connected in series with a resistance of 5 Ω and a battery of e.m.f. 5 volt and negligible internal resistance. The potential gradient along the wire in volt per metre is
(a) 0.1 (b) 0.2 (c) 0.3 (d) 0.4

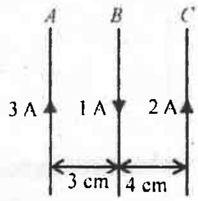
34. When cells are connected in parallel
(a) net emf becomes higher
(b) net emf becomes lower
(c) current capacity becomes higher
(d) current capacity becomes lower.

35. Wheatstone bridge is more accurate method of measuring the resistance because
(a) it has four resistor arms
(b) it is based on Kirchhoff's laws
(c) it does not involve Ohm's law
(d) it is a null method.

36. The magnetic field of a bar magnet resembles most closely in the magnetic field of
(a) a straight wire carrying a direct current
(b) a straight wire carrying an alternating current
(c) a wire loop carrying an alternating current
(d) a wire loop carrying a direct current.

37. A bar magnet is cut into two equal halves then
(a) the two halves are devoid of magnetism
(b) one piece has both south poles and the other both north
(c) each piece is a bar magnet with the same pole strength as original bar magnet having half length
(d) none of these.

38. Figure shows three long, straight and parallel conductors A, B and C carrying currents of 3 A, 1 A and 2 A respectively. A length of 0.5 m of the wire B experiences a force of



(a) 10×10^{-6} N from right to left
(b) 10×10^{-6} N from left to right
(c) 5.0×10^{-6} N from right to left
(d) 5.0×10^{-6} N from left to right.

39. A voltmeter of range 3 V and resistance 200 Ω cannot be converted into an ammeter of range
(a) 10 mA (b) 100 mA (c) 1 A (d) 10 A.

40. A small piece of a substance is repelled by magnetic field in whatever direction the magnetic field is applied. The substance is
(a) diamagnetic (b) paramagnetic
(c) ferromagnetic (d) ferrite.

41. An isolated magnetic pole is
(a) not yet observed
(b) is made of any ferromagnetic material
(c) is made of soft iron only
(d) is made of a diamagnetic material.

42. An induced e.m.f. is produced when a magnet is inserted into a coil. The magnitude of induced e.m.f. does not depend upon
(a) the number of turns in the coil
(b) the speed with which the magnet is moved
(c) strength of the magnet
(d) the resistivity of the wire of the coil.

43. When 100 volt d.c. supply is applied across a

solenoid, a current of 1.0 amp. flows in it. When 100 volt a.c. is applied across the same coil, the current drops to 0.5 amp. If the frequency of a.c. source is 50 Hz, the impedence and inductance of solenoid are
(a) 200 Ω and 0.55 H (b) 100 Ω and 0.86 H
(c) 200 Ω and 1.0 H (d) 100 Ω and 0.93 H.

44. Light of two different frequencies whose photons have energies 1 eV and 2.5 eV respectively, successively illuminate a metal of work function 0.5 eV. The ratio of maximum speeds of the emitted electrons will be
(a) 1 : 5 (b) 1 : 4 (c) 1 : 2 (d) 1 : 1.

45. The ionization energy of Li^{++} atom in ground state is equal to
(a) 13.6 × 9 eV (b) 13.6 J
(c) 13.6 erg (d) 13.6 × 10^{-19} J.

46. The decay constant λ of a radioactive sample
(a) decreases as the age of atoms increases
(b) increases as the age of atoms increases
(c) independent of the age
(d) depends on the nature of activity.

47. The ratio of the radii of the nuclei $_{13}Al^{27}$ and $_{52}Te^{125}$ is approximately
(a) 6 : 10 (b) 13 : 52 (c) 40 : 177 (d) 14 : 73.

48. The distinction between conductors, insulators and semiconductors is largely connected with
(a) their ability to conduct current
(b) the type of crystal lattice
(c) binding energy of their electrons
(d) relative widths of their energy gaps.

49. Truth table given here corresponds to
(a) AND gate
(b) OR gate
(c) NAND gate
(d) NOR gate.

Inputs		Outputs
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

50. The electromagnetic waves of frequency 2 MHz to 30 MHz are
(a) in ground wave propagation
(b) in sky wave propagation
(c) in microwave propagation
(d) in satellite propagation.

SOLUTIONS

1. **(d)** : $\dfrac{1}{\sqrt{\mu_0\varepsilon_0}}=\dfrac{1}{\sqrt{\dfrac{\mu_0}{4\pi}\times 4\pi\varepsilon_0}}$

Unit of $\mu_0/4\pi$ = newton/amp^2
and unit of $1/4\pi\varepsilon_0$ = newton × metre^2/coulomb^2.

2. **(d)** : $v = a_1t_1 = a_2t_2$

or, $t_1=\left(\dfrac{a_2}{a_1}\right)\times t_2=\left(\dfrac{4}{2}\right)t_2=2t_2$

Since $t_1 + t_2 = 3$ s, hence $t_1 = 2$ s and $t_2 = 1$ s.
Therefore, $v = 2 \times 2 = 4$ ms^{-1}.

As $x=ut+\dfrac{1}{2}at^2$, hence $x_1=\dfrac{1}{2}\times2\times4=4$ m.

and $x_2=\dfrac{1}{2}\times4\times1=2$ m. *i.e.* $x_1 + x_2 = 6$ m.

3. **(b)** : Range is same for angles of projection θ and (90 − θ).

$$t_1=\frac{2u\sin\theta}{g},\ t_2=\frac{2u\sin(90-\theta)}{g}=\frac{2u\cos\theta}{g}$$

Hence, $t_1t_2=\dfrac{4u^2\sin\theta\cos\theta}{g^2}=\dfrac{2}{g}\left[\dfrac{u^2\sin2\theta}{g}\right]=\dfrac{2R}{g}$.

4. **(d)** : Centripetal force = force of friction

or, $\dfrac{Mv^2}{r}=\mu R=\mu Mg$ or, $v=\sqrt{\mu rg}$.

5. **(a)** : Let the monkey climb up with acceleration a. The tension caused in the rope will be
$T = M(g + a)$, where M is the mass of the monkey.
Maximum value of T is $25g = 20(g + a)$.
Taking $g = 10$ ms^{-2}, it gives $a = 2.5$ ms^{-2}.

6. **(b)** : $W = 100 \times 10 \times 10$ J.
As efficiency of engine is 60%,

hence total work done = $\dfrac{100}{60}\times W$

$$=\frac{100}{60}\times100\times10\times10=\frac{10^5}{6}\text{ J.}$$

$\therefore$ $P=\dfrac{10^5}{6\times5\times10^3}$ kW = 3.3 kW.

7. **(c)** : Let the final velocity of the neutron be v_1.

Then $v_1=\dfrac{M_1-M_2}{M_1+M_1}u_1+\dfrac{2M_2}{M_1+M_2}u_2$

Now $u_1 = u$, $u_2 = 0$, $M_1 = 1$ and $M_2 = A$

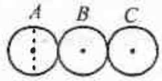
Hence $v_1=\dfrac{1-A}{1+A}u$

$\therefore$ Final kinetic energy of neutron = $\dfrac{1}{2}\times1\times v_1^2$

$$=\frac{1}{2}\left[\frac{1-A}{1+A}\right]^2u^2$$

Initial kinetic energy of neutron = $E = \frac{1}{2} \times 1 \times u^2$

$\therefore$ Final kinetic energy = $\left[\frac{1-A}{1+A}\right]^2 E.$

8. **(b)** : 

$AB = 2r$
$AC = 4r$

Taking A as the origin,

$$R_{CM} = \frac{m \times 0 + m \times 2r + m \times 4r}{3m} = 2r$$

$AB = 2r$, $AC = 4r$, from A. *i.e.* at B.

9. **(b)** : $g' = g - R_e\omega^2\cos^2\lambda$
Hence $g_p = g$ because at poles, $\lambda = 90°$ and $g_e = g - R_e\omega^2$ because at the equator $\lambda = 0°$.
Hence $g_p - g_e = R_e\omega^2$.

10. **(b)** : The pendulum oscillates under the effect of two accelerations g and a, which are in mutually perpendicular directions. Hence resultant acceleration increases because of which T decreases.

11. **(a)** : $v = \omega\sqrt{A^2 - x^2}$

$$= \frac{2\pi}{T}\left[\sqrt{A^2 - \frac{A^2}{4}}\right] = \frac{2\pi}{T} \times \frac{\sqrt{3}A}{2}.$$

12. **(c)** : $Y_1 = \frac{F_1}{(l_1/L_1)} = \frac{F_1}{\alpha_1 T}$ or, $F_1 = Y_1\alpha_1 T$

$$Y_2 = \frac{F_2}{(l_2/L_2)} = \frac{F_2}{\alpha_2 T} \text{ or, } F_2 = Y_2\alpha_2 T$$

where F_1 and F_2 are thermal stress.

As $F_1 = F_2$, hence $Y_1\alpha_1 = Y_2\alpha_2$. $\therefore \frac{Y_1}{Y_2} = \frac{\alpha_2}{\alpha_1} = \frac{3}{2}$.

13. **(a)** : Let the side of the cube be L. Then volume of the cube outside = volume of water displaced due to mass.
The water displaced is 300 g and its volume is 300 cm³.
Hence $3 \times L \times L = 300$ *i.e.* $L = 10$ cm.

14. **(a)** : Molecules move at random in all possible directions and momentum is a vector quantity.

15. **(d)** : $v = \sqrt{\frac{\gamma RT}{M}}$ and $C = \sqrt{\frac{3RT}{M}}$

$\therefore \frac{v}{C} = \sqrt{\frac{\gamma}{3}}$.

16. **(d)** : $n' = \frac{v + v_0}{v} \times n = \frac{320+2}{320} \times 800 = \frac{322}{320} \times 800$ Hz

$$n'' = \frac{v - v_0}{v} \times n = \frac{320-2}{320} \times 800 = \frac{318}{320} \times 800 \text{ Hz}$$

$\therefore n' - n'' = \frac{322-318}{320} \times 800 = \frac{4 \times 800}{320} = 10$ Hz.

17. **(c)** : Coeff. of cubical expansion of container = 3α when $\gamma > 3\alpha$, increase in the volume of the liquid is more than that of the vessel.

18. **(d)** : First law of thermodynamics is concerned with the conservation of energy and not with the flow of heat.

19. **(a)** : $\eta = \frac{T_1 - T_2}{T_1}$. Hence $\eta \propto (T_1 - T_2)$.

20. **(d)** : Let the temperature on the two sides be θ_1 and θ_2 and the temperature of interface be θ. Then

$$\frac{KA(\theta_1 - \theta_2)t}{2d} = \frac{K_1A(\theta_1 - \theta)t}{d} = \frac{K_2A(\theta - \theta_2)t}{d}$$

This gives $K(\theta_1 - \theta_2) = 2K_1(\theta_1 - \theta)$ and
$K(\theta_1 - \theta_2) = 2K_2(\theta - \theta_2)$

Solving, $K = \frac{2K_1K_2}{K_1 + K_2}$.

21. **(b)** : The image always remains as far behind the mirror as the object is in front.

22. **(a)** : $\frac{1}{16} = (1.5-1)\left[\frac{1}{R} - \frac{1}{\infty}\right]$

or, $\frac{1}{16} = \frac{0.5}{R}$ or, $R = 8$ cm.

23. **(b)** : Critical angle will be $\sin^{-1}(1/1.5) = 41.8°$. The angle of incidence inside the prism will be 45°. Since it is more than critical angle, the light ray will undergo total internal reflection.

24. **(c)** : $I_{max} = I_1 + I_2 + 2\sqrt{I_1I_2}$
and $I_{min} = I_1 + I_2 - 2\sqrt{I_1I_2}$.

25. **(c)** : As charge on a metal sphere can be supposed to be placed at the centre just like a point charge and force on point charge $\propto$ 1/(distance)².

26. **(a)** : Initial force = $F_1 = \frac{1}{4\varepsilon_0}\frac{(+10)(-20)}{x^2}$

Final force = $F_2 = \frac{1}{4\pi\varepsilon_0}\frac{(-5)(-5)}{x^2}$

[charge on each ball = (10 − 20)/2 = −5 units]

$$\frac{F_1}{F_2} = \frac{-200}{25} = \frac{-8}{1}.$$

27. **(d)** : As electric field is directed from south to north and $E = -(\Delta V/\Delta x)$
Hence rate of change of potential will not be zero along north or south or north-south. It is zero along east and west.

28. (d) : For 1000 V capacitor, four capacitors must be joined in series. But capacity of one such row of four capacitors will be equal to 2 μF. Hence 8 such rows of four capacitors each, must be joined in parallel to form a 16 μF 1000 V capacitor.

29. (a) : It is equivalent to a parallel combination of three capacitors.

$\therefore \quad C_{eff} = C_1 + C_2 + C_3 = 9\ \mu F.$

30. (d) : α is +ve for copper but −ve for germanium.

31. (d) : $P_1 = P_2 = 50$ watt

$$P_S = \frac{P_1 P_2}{P_1 + P_2} = \frac{50 \times 50}{100} = 25 \text{ watt.}$$

32. (c) : $R_{AB} = \frac{30 \times 60}{30 + 60} = 20\ \Omega,\ i = \frac{2}{20} = \frac{1}{10}$ amp.

33. (d) : $i = \frac{5}{20+5} = \frac{1}{5}$ amp.

$$V = i \times 20 = \frac{1}{5} \times 20 = 4 \text{ volt.}$$

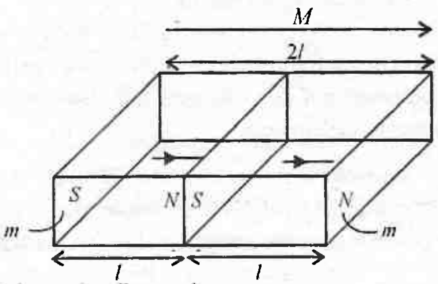
i.e. $K = \frac{V}{L} = \frac{4 \text{ volt}}{10 \text{ metre}} = 0.4$ volt/metre.

34. (c) : In parallel combination of cells, e.m.f. remain same but current capacity gets increased because currents due to all the cells are added up.

35. (d) : In null position, no current flows through the galvanometer connected in diagonal arm of the bridge. It is due to this reason that Wheatstone bridge is more accurate method for determining resistance.

36. (d) : A current carrying loop is equivalent to a bar magnet or a magnetic dipole having magnetic dipole moment equal to iA, where A is the area of the loop.

37. (c) :



It is clear from the figure that

$$\vec{M} = \vec{M}_1 + \vec{M}_2 \quad \text{or,} \quad m2l = m'l + m'l$$

or, $m' = m$.

38. (d) : Total magnetic field produced by conductors A and C at the position of $B = B_R = B_A - B_C$.

(B_A is ⊗ and B_C is ⊙)

Hence, $B_R = \frac{\mu_0 \times 3}{2\pi \times 3 \times 10^{-2}} - \frac{\mu_0 \times 2}{2\pi \times 4 \times 10^{-2}}$

$= 2 \times 10^{-5} - 10^{-5} = 10^{-5}$ T.

$F = B_R il \sin 90° = 10^{-5} \times 1 \times 0.5 = 5 \times 10^{-6}$ N.

As B_R is ⊗, hence according to right hand palm rule, force will be directed from left to right.

39. (a) : Here $i_g = \frac{3 \text{ V}}{200\ \Omega} = 0.015$ amp. = 15 mA.

So, new range cannot be less than 15 mA.

40. (a) : A diamagnetic substance is repelled by a strong magnet.

41. (a) : A magnetic pole does not exist in nature because we cannot separate a north pole from a south pole.

42. (d) : Induced emf depends only on the rate of change of total magnetic flux linked with the coil. It is independent of the resistance of the coil.

43. (a) : For d.c., $\omega = 0$,

hence $Z = R = (E_{rms}/I_{rms}) = 100/1 = 100\ \Omega$.

For a.c., $Z = \sqrt{R^2 + (2\pi f L)^2} = \sqrt{(100)^2 + (100\pi L)^2}$

Now, $Z = \frac{100}{0.5} = 200\ \Omega$,

hence $200 = \sqrt{(100)^2 + (100\pi L)^2}$.

44. (c) : $\left[\frac{1}{2}m(v_{max})^2\right]_I = (h\upsilon)_I - W$

$= 1 \text{ eV} - 0.5 \text{ eV} = 0.5 \text{ eV}$

$$\left[\frac{1}{2}m(v_{max})^2\right]_{II} = (h\upsilon)_{II} - W$$

$= 2.5 \text{ eV} - 0.5 \text{ eV} = 2.0 \text{ eV}$

$$\therefore \quad \frac{(v_{max})_{II}}{(v_{max})_I} = \left(\frac{2.0}{0.5}\right)^{1/2} = 2 \quad \text{or,} \quad \frac{(v_{max})_I}{(v_{max})_{II}} = \frac{1}{2}.$$

45. (a) : $(I.E.)_Z = Z^2 (I.E.)_H = (3)^2 \times 13.6$ eV.

46. (c)

47. (a) : Radius of nucleus, $R = R_0(A)^{1/3}$

where A is the mass number

$R_{Al} \propto (27)^{1/3}$, $R_{Te} \propto (125)^{1/3}$.

48. (d) : Forbidden energy gap is maximum in case of insulators, less for semiconductors. For conductors, there is no energy gap.

49. (b) : For OR gate $Y = A + B$.

50. (b) : The electromagnetic waves of frequency 2 MHz to 30 MHz are used in sky wave propagation.

Practice Paper for CBSE Mains

Exam on 14th May 2006

1. (a) The maximum and the minimum magnitudes of the resultant of two given vectors are 17 units and 7 units respectively. If these two vectors are directed at right angles to each other, find the magnitude and direction of their resultant.
(b) Given the velocity of sound (v) depends upon the elasticity of the medium (E) and the density (d), derive the relation.

2. (a) If the intensity at a point in an electric field be zero, will the potential there be also zero? If the potential at the point be zero, will the intensity be zero?
(b) A resistance of 1000 Ω and a uniform variable resistance of total resistance 400 Ω are connected in series to a battery of e.m.f. 6 V and a negligible internal resistance. What is the potential difference across the 1000 Ω resistor when (i) a quarter, (ii) half of the variable resistance is in the circuit.

3. (a) A spring balance has a scale that reads from 0 to 50 kg. The length of the scale is 20 cm. A body suspended from this spring, when displaced and released, oscillates with a period of 0.60 s. What is the weight of the body?
(b) A wheel is rotating about an axis passing through its centre and perpendicular to its plane. If it moves with constant angular velocity or constant angular acceleration, can it have a radial or tangential acceleration?
(c) A solid cylinder of mass 20 kg rotates about its axis with angular speed 100 s^{-1}. The radius of the cylinder is 0.25 m. What is the kinetic energy associated with the rotation of the cylinder? What is the magnitude of angular momentum of the cylinder about its axis.

4. (a) Compare the velocity of sound in oxygen and hydrogen at 10°C and under a pressure of 76 cm of mercury when oxygen is 16 times denser than hydrogen.
(b) One of the two clocks on earth is controlled by a pendulum and other by a spring. If both the clocks be taken to the moon, then state with reason whether the clocks will show accurate time or not.

5. (a) Only certain definite lines are found in the atomic spectra of substances. Explain why. Hydrogen atom has only one electron, but its emission spectrum has many lines. Explain it.
(b) An X-ray tube produces a continuous spectrum of radiation with its short wavelength end at 0.45 Å. What is the maximum energy of a photon in the radiation.
(c) Why does the electrical conductivity of a pure semiconductor increase with rise in temperature?

6. (a) In changing the state of a gas adiabatically from an equilibrium state A to another equilibrium state B, an amount of work equal to 22.3 J is done on the system. If the gas is taken from the state A to B via a process in which the net heat absorbed by the system is 9.35 cal, how much is the net work done by the system in latter case? (1 cal = 4.19 J).
(b) What part does the specific heat of water play in causing sea-breeze?

7. (a) A simple pendulum PO 2.0 m long is displaced from its position of rest into the position PR and then set free. What would be its speed when it is passing through the point O assuming that 3% of the initial energy is dissipated against air resistance.
(b) The initial and final temperatures of water in a container are observed as 16 ± 0.5°C and 41 ± 0.1°C. What is the rise in the temperature of water?

8. (a) The displacement y (in m) of a body varies with time t (in sec) as $y = -\frac{2}{3}t^2 + 16t + 2$.
How long does the body take to come to rest?
(b) Machine bearings are often made of one metal while their rotating shafts are made of another. Why?
(c) Calculate longest and shortest wavelength in Balmer series.

9. (a) An electric motor runs on a d.c. source of e.m.f. ε and internal resistance r. Show that the power

output of the source is maximum when the current drawn by a motor is $\varepsilon/2r$.

(b) A current of 5 A flows through a copper wire of a cross section 3 mm². Obtain the drift velocity of the electrons. Given there is one free electron per atom, molecular mass = 63.5 g/mol, density of copper = 8.92×10^3 kgm^{-3}.

(c) A bar magnet 4 cm long is held vertically with its north pole resting on a horizontal table. A neutral point is located on the table 3 cm from the lower end of the magnet. Find the moment of the magnet.
Given, H = 0.2 oersted.

10. **(a)** The speed of sound in moist air is greater than in dry air, why? Will the speed of sound in moist hydrogen be greater than in dry hydrogen?

(b) The refractive index of glass is 1.5. What is the speed of light in glass? (Speed of light in vacuum is 3.0×10^8 ms^{-1}).

(c) The image of a candle formed by a convex lens is obtained, if the lower half of the lens is painted black and completely opaque?

SOLUTIONS

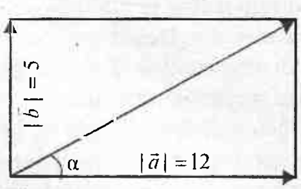
1. The resultant of two given vectors has its maximum magnitude when the vectors are parallel to each other ($\theta = 0°$) and its minimum magnitude when they are anti-parallel to each other ($\theta = \pi$). Hence if $\vec{a}$ and $\vec{b}$ are the two given vectors, we have

Maximum magnitude of their resultant $= |\vec{a}| + |\vec{b}| = 17$, and

Minimum magnitude of their resultant $= |\vec{a}| - |\vec{b}| = 7$

Solving these two equations, we get $|\vec{a}| = \dfrac{17+7}{2} = 12$

and $|\vec{b}| = \dfrac{17-7}{2} = 5$.



When these two vectors act at right angles to each other, we have magnitude of there resultant $= |\vec{R}| = \sqrt{12^2 + 5^2} = 13$

This resultant is inclined at an angle α to the vector $\vec{a}$

where $\tan\alpha = \dfrac{5}{12} = 0.4167 \;\therefore\; \alpha = \tan^{-1}(0.4167)$

(b) Let the relation be represented by equation,

$$v \propto E^a \times d^b$$

Writing the dimensions on both sides,

$$[LT^{-1}] \propto [ML^{-1}T^{-2}]^a [ML^{-3}]^b$$

or $\quad [M^0LT^{-1}] \propto M^{a+b} L^{-a-3b} T^{-2a}$

By the principle of homogeneity of dimensions, we have

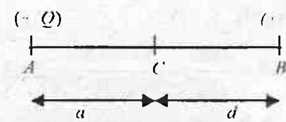
$$0 = a + b$$
$$1 = -a - 3b$$
$$-1 = -2a$$
$$a = 1/2\ ,\ b = -1/2$$

Hence the relation is $[LT^{-1}] \propto [ML^{-1}T^{-2}]^{1/2}\,[ML^{-3}]^{-1/2}$

or $\quad v \propto E^{1/2} d^{-1/2}$ i.e., $\quad v \propto \sqrt{\dfrac{E}{d}}$

or $\quad v = k\sqrt{\dfrac{E}{d}}$ where k is the constant.

2. **(a)** If the intensity at a point in an electric field be zero, the potential may not be zero there. For example, if two like charges of equal magnitude Q be separated by a distance $2d$ as shown in figure, the intensity at C (the mid point of AB) will be zero, but the potential



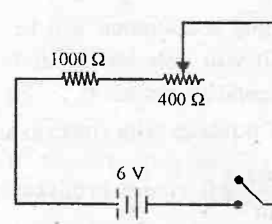
at C will be given by $V_C = \dfrac{Q}{d} + \dfrac{Q}{d}$

$$= \frac{2Q}{d}, \text{ which is not equal to zero.}$$

Also, it is known that the potential inside a charged hollow conductor is constant having some value but there is no electric field there.

If the potential at a point be zero, then the intensity may not be zero there. For example, two equal and opposite charges are placed at a distance apart. Then the potential at any point on the perpendicular bisector of the line joining the two charges will be zero but there will be a resultant intensity at that point whose direction is parallel to the line joining the charges.

(b) The circuit is shown in figure, (i) when a quarter of the variable resistance is in circuit, the total resistance of the circuit, is $\left(1000 + \dfrac{400}{4}\right)\Omega$ or $1100\ \Omega$.



Hence current $i = \dfrac{V}{R} = \dfrac{6}{1100}$ A

$\therefore$ potential difference across the 1000 Ω resistance is

$= \frac{6}{1100} \times 1000 \text{ V} = 5.45 \text{ V}$

(ii) In the second situation, the total resistance of the circuit is $\left(1000 + \frac{400}{2}\right)\Omega = 1200\,\Omega$.

Hence current $i = \frac{V}{R} = \frac{6}{1200}$ A

$\therefore$ Potential difference across the $1000\,\Omega$ resistance is

$$= \frac{6}{1200} \times 1000 \text{ V} = 5 \text{ V}.$$

3. **(a)** We are given that a weight of 50 kg displaces the spring through 20 cm. Hence, the force constant of the spring is

$$\therefore \quad k = \frac{mg}{x} = \frac{50 \times 9.8}{20 \times 10^{-2}} = 24.5 \times 10^{2} \text{ Nm}^{-1}.$$

Let m be the suspended mass. The time period of the oscillating mass is given by

$$T = 2\pi\sqrt{\frac{m}{k}} \qquad \therefore\ 0.60 = 2\pi\sqrt{\frac{m}{24.5 \times 10^2}}$$

or $$\frac{(0.60)^2}{4\pi^2} = \frac{m}{24.5 \times 10^2}$$

$$\therefore\ m = \frac{(0.60)^2}{4\pi^2} \times 24.5 \times 10^2 \text{ kg}$$

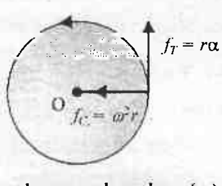
$\therefore$ Weight of the body $= \frac{0.36}{4\pi^2} \times 24.5 \times 9.8 \text{ N} \simeq 219 \text{ N}.$

(b) The radial acceleration or centripetal acceleration

$$f_C = \omega^2 r$$

Tangential acceleration, $f_T = r\alpha = r\frac{d\omega}{dt}$.

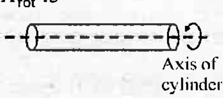
So, if the wheel rotates with constant angular velocity (ω), then $\frac{d\omega}{dt} = 0$. So, tangential acceleration will be zero. It will only have radial (centripetal acceleration).



But, if it rotates with constant angular acceleration (α), then $\frac{d\omega}{dt} \neq 0$. Hence, in this case, it will have both radial and tangential acceleration as shown in figure.

(c) The rotational kinetic energy K_{rot} is

$$K_{rot} = \frac{1}{2} I \omega^2$$



The moment of inertia, I, of the cylinder about its own axis is $I = \frac{1}{2}MR^2 = \frac{1}{2} \times 20 \times (0.25)^2 = 0.625 \text{ kgm}^2$

Given $\omega = 100 \text{ s}^{-1}$

$$\therefore\ K_{rot} = \frac{1}{2} \times 0.625 \times (100)^2 \text{ J} = 3125 \text{ J}.$$

4. **(a)** Let v_1 and v_2 be the velocities of sound in oxygen and hydrogen respectively and ρ_1, ρ_2 be their corresponding densities respectively. Since sound travels under the same conditions of temperature and pressure and moreover both oxygen and hydrogen are diatomic gases having the same value for γ, the ratio of the two specific heats.

$$\therefore\ \frac{v_1}{v_2} = \sqrt{\frac{\rho_2}{\rho_1}}. \quad \text{Here, } \rho_2 = 1,\ \rho_1 = 16$$

$$\therefore\ \frac{v_1}{v_2} = \sqrt{\frac{1}{16}} = \frac{1}{4}. \quad \text{Hence } v_2 = 4v_1$$

Velocity of sound in hydrogen = 4 times the velocity of sound in oxygen.

(b) The time period of the clock controlled by a spring depends upon the force constant of the spring and the mass of the body suspended by it, so it will not be affected when it is taken to the moon. Hence the clock based on spring will give the same time on the moon as well as on the earth. But, in case of the clock controlled by a pendulum, time period is inversely proportional to the square root of acceleration due to gravity, *i.e.* $T \propto \frac{1}{\sqrt{g}}$.

On the surface of the moon the value of g is much less compared to that on the earth. So the time period will be more and hence the clock will go slow.

5. **(a)** The atomic spectrum of a substance is obtained due to transitions of electrons from one energy state (orbit) to another. Atom has only certain definite energy states corresponding to the stationary or permissible orbits of the electron. Hence only certain definite frequencies of radiation emitted by the atoms are possible resulting in line spectrum of the atom.

When a certain quantity of hydrogen gas is excited by supplying energy from outside source, millions of hydrogen atoms are excited. These atoms absorb different amounts of energy and the electrons of the atoms jump to quantum orbits of different energy levels. These electrons make transitions to the ground state by giving up different quantities of energy. As a result, according to Bohr's frequency postulate, they give rise to spectral lines corresponding to the photons of different frequencies.

Contd. onpage no. 70

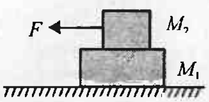
Very Similar
MODEL TEST PAPER
for BHU (MAINS) 2006

Exam on 18th June 2006

SECTION - A

1. A ball is dropped downwards. After 1 second another ball is dropped downwards from the same point. What is the distance between them after 3 seconds?
(a) 25 m (b) 20 m (c) 50 m (d) 9.8 m.

2. A 30 kg slab rests on a frictionless floor. A 10 kg block rests on the top of the slab. The coefficient of static friction between the block and the slab is 0.5 and that of dynamic friction is 0.15. A force of 40 N is applied on the block. The resulting acceleration of the slab would be



(a) zero (b) 2 m/s^2 (c) 1 m/s^2 (d) 5 m/s^2.

3. A ball of mass m_1 collides elastically and head on with another ball of mass m_2 initially at rest. In which of the following cases transfer of momentum will be maximum?
(a) $m_1 > m_2$ (b) $m_1 < m_2$
(c) $m_1 = m_2$ (d) cannot be said.

4. A hollow cylinder and a solid cylinder having the same mass and same diameter are released from rest simultaneously from the top of an inclined plane. Which will reach the bottom first?
(a) solid cylinder (b) hollow cylinder
(c) both will reach the bottom together
(d) the one having greater density.

5. A substance breaks down by a stress of 10^6 N/m^2. If the density of the material of the wire is 3×10^3 kg/m^3 then the length of the wire of that substance which will break under its own weight when suspended vertically is
(a) 3.4 m (b) 34 m (c) 340 m (d) 3400 m.

6. A satellite is orbiting around the earth with a period T. If the earth suddently shrinks to 2/3rd of its radius without change in mass, the period of revolution of the satellite will be
(a) $T/\sqrt{2}$ (b) T (c) $T/2$ (d) $2T$.

7. A tank has an orifice at its bottom. The volume of liquid flowing out per second from the orifice does not depend upon
(a) the area of the orifice
(b) height of the liquid level above the orifice
(c) density of the liquid
(d) value of acceleration due to gravity.

8. Two dissimilar springs fixed at one end are stretched by 10 cm and 20 cm respectively. When masses m_1 and m_2 are suspended at their lower ends. When displaced slightly from their mean position and released, they will oscillate with period in the ratio
(a) 1 : 2 (b) 2 : 1 (c) 1 : 1.41 (d) 1.41 : 4.

9. In a refrigerator, heat from inside at 277 K is transfered to the room at 300 K. How many joules of heat energy will be delivered to the room for each joule of electrical energy consumed ideally
(a) 13 J (b) 26 J (c) 12 J (d) 11.5 J.

10. A man on the ground finds that when he sees a jet plane just over his head, the sound is heard at an angle of 30° with the vertical from his left. If the velocity of sound is v, what is the velocity of the jet plane?
(a) $v/2$ (b) $2v$ (c) $v\frac{2}{\sqrt{3}}$ (d) $v\frac{\sqrt{3}}{2}$

11. Two charges q_1 and q_2 repel each other with a force of 0.2 N. What will be the force exerted by q_1 and q_2 when a third charge is placed near them?
(a) 0.2 N (b) > 0.2 N
(c) < 0.2 N
(d) less than 0.2 if q_1 and q_2 are similar and more than 0.1 if q_1 and q_2 are dissimilar.

12. A wire of resistance R is bent in the form of a circle. The resistance between two points on the circumference of the wire and at the end of a diameter of the circle is
(a) $R/4$ (b) $R/8$ (c) $R/16$ (d) $R/32$.

13. The water in an electric kettle begins to boil in 15 minutes after being switched on. Using the same main supply, by what percentage the length of the wire used as the heating element should be increased or

decreased if the water is to boiled in 10 minutes?
(a) decreased by 33% (b) increases by 33%
(c) decreased by 67% (d) increased by 67%.

14. A circular coil of radius r carries a current i. The magnetic field at its centre is B. At what distance from the centre, on the axis of the coil, the magnetic field will be $B/8$?
(a) $3r$ (b) $2r$ (c) $\sqrt{3}r$ (d) $\sqrt{2}r$.

15. The sensitivity of a tangent galvanometer will increase when
(a) number of turns in the coil is deceased
(b) number of turns in the coil is increased
(c) radius of the coil is increased
(d) none of these.

16. Which of the following is not a property of light?
(a) it involves transportation of energy
(b) it can travel through vacuum
(c) it has infinite speed
(d) it can travel in a material medium.

17. A convex mirror of focal length f produces an image $1/n$ times the size of the object. The distance of the object from the mirror is
(a) $(n+1)f$ (b) $(n-1)f$
(c) $\left(\frac{n-1}{n}\right)f$ (d) $\left(\frac{n+1}{n}\right)f$.

18. A Young's double slit arrangement produces interference fringes for sodium light $\lambda = 5890$ Å that are 0.2° apart. What is the angular fringe separation if the entire arrangement is immersed in water whose refractive index is 4/3?
(a) 0.10° (b) 0.15° (c) 0.20° (d) 0.30°.

19. The focal length of a thin convex lens for red and blue coloured are 100.9 and 99.5 cm. The dispersive power of the lens is
(a) 1.005 (b) 0.995 (c) 0.02 (d) 0.01

20. If E_1, E_2 and E_3 are three respective kinetic energies of an electron, an alpha particle and a proton each having the same de Broglie wavelength, then
(a) $E_1 > E_3 > E_2$ (b) $E_2 > E_3 > E_1$
(c) $E_1 = E_2 = E_3$ (d) $E_1 > E_2 > E_3$.

21. The de Broglie wavelength of a neutron at 27°C is λ. The wavelength at 927°C will be
(a) $\lambda/9$ (b) $\lambda/4$ (c) $\lambda/3$ (d) $\lambda/2$.

22. In the nuclear process, ${}_6C^{11} \rightarrow {}_5B^{11} + \beta^+ + X$, X stands for
(a) proton (b) electron
(c) neutron (d) neutrino.

23. For a common emitter circuit the current gain of a transistor is 60. If the emitter current is 6.6 mA, the base current is
(a) 0.10 mA (b) 6.5 mA
(c) 0.66 mA (d) none of these.

24. For detecting intensity of light we use
(a) photo diode in forward bias
(b) photo diode in reverse bias
(c) LED in forward bias (d) LED in reverse bias.

25. If $A = 1 = B$, then in terms of Boolean algebra $\overline{A} + B$ equals
(a) $A + B$ (b) $\overline{B}$ (c) $\overline{A}$ (d) A or B.

SECTION - B

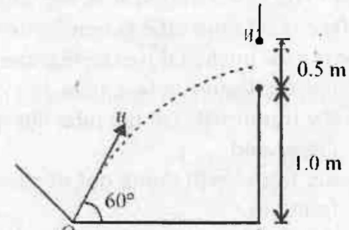
***Direction:** In the following questions more than one of the answers given may be correct. Select the correct answers and mark it according to the code.*

Code:
(a) 1, 2 and 3 are correct (b) 1 and 2 are correct
(c) 2 and 4 are correct (d) 1 and 3 are correct

26. Which of the following statements are true for a moving body?
1. If its velocity changes, its speed must change and it must have some acceleration.
2. If its velocity changes, its speed may or may not change, and it must have some acceleration.
3. If its speed changes but direction of motion does not change, its velocity may remain constant.
4. If its speed changes, its velocity must change and it must have some acceleration.

27. If two bodies are in motion with velocities $\vec{v}_1$ and $\vec{v}_2$, then resultant velocity can be
(1) $|\vec{v}_0| = \sqrt{v_1^2 + v_2^2}$ (2) $|\vec{v}_0| = |\vec{v}_1 \pm \vec{v}_2|$
(3) $|\vec{v}_0| = 0$ (4) $v_0 > c$, speed of light.

28. A ball is dropped onto a pad at O and rebounds with a velocity u at an angle 60° with the horizontal as shown in figure. The ball will enter a window W of width 0.5 m at a height 1 m, if u is



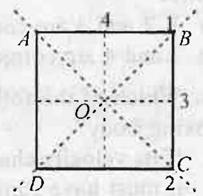
(1) 50 m/s (2) 1 m/s (3) 6 m/s (4) 5 m/s.

29. If a dipole is situated in a non-uniform field,
(1) $\Sigma \vec{F} = 0; \Sigma\tau = 0$ (2) $\Sigma F \neq 0$, but $\Sigma\tau = 0$
(3) $\Sigma F = 0$, but $\Sigma\tau \neq 0$ (4) $\Sigma F \neq 0; \Sigma\tau \neq 0$.

30. A reference frame attached to earth
(1) cannot be inertial frame as earth is rotating about its axis
(2) is inertial frame by definition
(3) cannot be inertial frame as earth is moving around its axis
(4) is inertial frame because Newton's laws are applicable in this frame.

31. A heavy stone is thrown from a cliff of height h in a given direction. The speed with which it hits the ground
(1) must be larger than the speed of projection
(2) must be independent of speed of projection
(3) must depend on the speed of projection
(4) may be smaller than the speed of projection.

32. The moment of inertia of a thin square plate $ABCD$ of uniform thickness about an axis passing through the centre O and perpendicular to the plate is (where I_1, I_2, I_3, I_4 are moments of inertia about axes 1, 2, 3 and 4 which are in the plane of the plate).



(1) $I_1 + I_2$ (2) $I_3 + I_4$
(3) $I_1 + I_3$ (4) $I_1 + I_2 + I_3 + I_4$.

33. An astronaut, inside an earth satellite experiences weightlessness because
(1) the centripetal gravitational force on the astronaut is cancelled by the centrifugal force
(2) no reaction is exerted by floor of the satellite
(3) he is far away from the earth's surface
(4) no external force is acting on him.

34. When a capillary tube is dipped in a liquid, the liquid rises to a height h in the tube. The free liquid surface inside the tube is hemispherical in shape. The tube is now pushed down so that the height of the tube outside the liquid is less than h
(1) the liquid will fill the tube but not come out of its upper end
(2) the liquid will come out of the tube like in small fountain
(3) the free liquid surface inside the tube will not be hemispherical
(4) the liquid will ooze out of the tube slowly.

35. If in a thermodynamical process the initial pressure and volume are equal to the final pressure and volume respectively, then
(1) final internal energy must be equal to initial
(2) final temperature must be equal to initial
(3) net work done on the system must be zero
(4) net heat given to the system is zero.

36. Which of the following functions represent simple harmonic motion?
(1) $\sin 2\omega t$ (2) $\sin\omega t + 2\cos\omega t$
(3) $\sin^2\omega t$ (4) $\sin\omega t + \cos 2\omega t$.

37. A transverse sinusoidal wave of amplitude a, wavelength λ and frequency f is travelling on a stretched string. The maximum speed of any point on the string is $v/10$, where v is the speed of propagation of the wave. If $a = 10^{-3}$ m and $v = 10$ m/s, then λ and f are given by
(1) $\lambda = 2\pi \times 10^{-2}$ m (2) $\lambda = 10^{-3}$ m
(3) $f = 10^3/(2\pi)$ Hz (4) $f = 10^4$ Hz.

38. The capacitance of a parallel-plate capacitor is C_0 when the region between the plates has air. This region is now filled with a dielectric slab of dielectric constant K. The capacitor is connected to a cell of emf E, and then slab is taken out. Then
(1) charge $EC_0(K - 1)$ flows through the cell
(2) energy $C_0E^2(K - 1)$ is absorbed by the cell
(3) the external agent has to do $\frac{1}{2}E^2C_0(K-1)$ amount of work to take the slab out
(4) the energy stored in the capacitor is reduced by $E^2C_0(K - 1)$.

39. Two electric bulbs rated 25 W, 220 V and 100 W, 220 V are connected in series across a 220 V source. The 25 W and 100 W bulbs bulbs now draw powers P_1 and P_2 respectively, then
(1) $P_1 = 16$ W (2) $P_1 = 4$ W
(3) $P_2 = 4$ W (4) $P_2 = 16$ W.

40. Which of the following statements is/are incorrect?
(1) both Peltier and Joule effects are reversible
(2) both Peltier and Joule effects are irreversible
(3) Joule effect is reversible, whereas Peltier effect is irreversible
(4) Joule effect is irreversible, whereas Peltier effect is reversible.

41. A ring carrying clockwise current is placed in a uniform magnetic field. The direction of the field is

perpendicular to the plane of the ring inwards
(1) there is not net force on the ring
(2) the ring will tend to contract
(3) the ring will tend to expand
(4) torque on the coil is maximum.

42. The meniscus of a liquid obtained in one of the limbs of a narrow U-tube is held in an electromagnet with the meniscus in line with the field. The liquid is seen to rise. This indicates that the liquid is
(1) paramagnetic (2) ferromagnetic
(3) diamagnetic (4) non-magnetic.

43. The magnetic flux linked with a coil is ϕ and the emf induced in it is e. Then
(1) if $\phi = 0$, e must be 0
(2) if $\phi \neq 0$, e cannot be 0
(3) if e is not 0, ϕ may not be zero
(4) none of the above is correct.

44. Which of the following Maxwell's equations have sources of E and B ?
(1) $\oint_S \vec{E} \cdot d\vec{s} = \frac{q}{\varepsilon_0}$
(2) $\oint_S B \cdot d\vec{l} = \mu_0 I + \mu_0 \varepsilon_0 \frac{d}{dt} \oint_S \vec{E} \cdot d\vec{s}$
(3) $\oint_S \vec{E} \cdot d\vec{l} = -\frac{d}{dt} \oint_S \vec{B} \cdot d\vec{s}$
(4) $\oint_S B \cdot d\vec{s} = 0$.

45. When lights of different colours moves through water, they must have different
(1) wavelengths (2) amplitudes
(3) velocities (4) frequencies.

46. A bird flies down vertically towards a water surface. To a fish inside the water, vertically below the bird, the bird will appear to
(1) be farther away than its actual distance
(2) be closer than its actual distance
(3) move faster than its actual speed
(4) move slower than its actual speed.

47. Photoelectric effect supports the quantum nature of light because
(1) there is a minimum frequency of light below which no photoelectrons are emitted
(2) the maximum kinetic energy of photoelectrons depends only on the frequency of light and not on its intensity
(3) even when the metal surface is faintly illuminated, the photoelectrons leave the surface immediately
(4) electric charge of photoelectrons is quantised.

48. An electron in a hydrogen atom makes a transition from $n = n_1$ to $n = n_2$. The time period of the electron in the initial state is eight times that in the final state. The possible values of n_1 and n_2 are
(1) $n_1 = 4$, $n_2 = 2$ (2) $n_1 = 6$, $n_2 = 3$
(3) $n_1 = 8$, $n_2 = 1$ (4) $n_1 = 8$, $n_2 = 2$.

49. Semiconductor devices are
(1) temperature dependent
(2) voltage dependent (3) current dependent
(4) none of these.

50. Which of the following statements concerning the depletion zone of an unbiased p-n junction is (are) true?
(1) the width of the zone is independent of the densities of the dopants (impurities)
(2) the width of the zone is dependent of the densities of the dopants
(3) the electric field in the zone is provided by the electrons in the conduction band and the holes in the valence band
(4) the electric field in the zone is produced by the ionized dopant atoms.

SOLUTIONS

1. (a) : The ball A has fallen for 3 seconds, the distance travelled,

$$s_1 = \frac{1}{2} g t_1^2 = \frac{1}{2} \times 10 \times 3^2 = 45 \text{ m.}$$

The ball B has fallen for 2 seconds, the distance travelled,

$$s_2 = \frac{1}{2} g t_2^2 = \frac{1}{2} \times 10 \times 2^2 = 20 \text{ m.}$$

Separation between the two balls,
$s_1 - s_2 = 45 - 20 = 25$ m.

2. (c) : Here force of limiting friction $= \mu M_2 g = 0.5 \times 10 \times 10 = 50$ N
As applied force is 40 N *i.e.* less than the force of limiting friction, block shall not move.
The slab will however, move with acceleration

$$a = \frac{F}{M_1 + M_2} = \frac{40}{(30+10)} = 1 \text{ m/s}^2.$$

3. (c) : Transfer of kinetic energy and hence momentum is maximum when $m_1 = m_2$.

4. (a) : For solid cylinder, $I_s = \frac{1}{2} MR^2$
For hollow cylinder, $I_h = MR^2$

As $I_h > I_s$, therefore angular acceleration, $\alpha_h < \alpha_s$ Hence solid cylinder reaches the bottom first.

5. **(b)** : Breaking force = breaking stress × area of cross section = weight of wire

$\therefore\ 10^6 \times A = Al \times \rho g$

or, $l = \frac{10^6}{\rho g} = \frac{10^6}{3\times 10^3 \times 9.8} \approx 34$ m.

6. **(b)** : $T = \frac{2\pi r}{v} = 2\pi r\sqrt{\frac{r}{GM}}$

where r is the radius of the orbit of satellite. As T is independent of radius of earth, hence T remains unchanged, when earth shrinks.

7. **(c)** : Volume of liquid flowing out per second through the orifice $= Av = A\sqrt{2gh}$; which is independent of density of liquid.

8. **(c)** : $m_1 g = k_1 \times 10$; $m_2 g = k_2 \times 20$

So, $\frac{m_1}{k_1} = \frac{10}{g}$ and $\frac{m_2}{k_2} = \frac{20}{g}$

$\therefore\ T_1 = 2\pi\sqrt{\frac{m_1}{k_1}} = 2\pi\sqrt{\frac{10}{g}}$; $T_2 = 2\pi\sqrt{\frac{m_2}{k_2}} = 2\pi\sqrt{\frac{20}{g}}$

So, $\frac{T_1}{T_2} = \sqrt{\frac{10}{20}} = \frac{1}{1.414}$.

9. **(a)** : Coefficient of performance $= \frac{Q_2}{W} = \frac{T_2}{T_1 - T_2}$

$\frac{Q_2}{1} = \frac{277}{300-277} = \frac{277}{23} = 12$ J

$\therefore\ Q_1 = Q_2 + W = 12 + 1 = 13$ J.

10. **(a)** : If V is velocity of jet, then as per question,

$\sin 30° = \frac{V}{v}$ or $V = v\sin 30° = \frac{v}{2}$.

11. **(a)** : Force exerted by q_1 and q_2 on each other remains the same (= 0.2 N) and is not affected by the presence/absence of any other charge.

12. **(a)** : In this arrangement, there are two resistances each of value $R/2$ connected in parallel. So the equivalent resistance is $R/4$.

13. **(a)** : Heat produced,

$H = \frac{V^2 t}{R} = \frac{V^2 t}{(\rho l/A)}$ $\left(\because R = \frac{\rho l}{A}\right)$

According to question, $H = \frac{V^2 t_1 A}{\rho l_1} = \frac{V^2 t_2 A}{\rho l_2}$

$\therefore\ \frac{t_1}{t_2} = \frac{l_1}{l_2}$ or, $l_2 = \frac{t_2 l_1}{t_1} = \frac{10 l_1}{15} = \frac{2}{3} l_1$

% decrease in length $= \frac{l_1 - l_2}{l_1} \times 100 = \left(1 - \frac{l_2}{l_1}\right) \times 100$

$= \left(1 - \frac{2}{3}\right) \times 100 = 33\%$.

14. **(c)** : Magnetic field at centre, $B = \frac{\mu_0}{4\pi}\frac{2\pi i}{r}$

Magnetic field at a point on the axis,

$B' = \frac{\mu_0}{4\pi}\frac{2\pi i r^2}{(r^2 + x^2)^{3/2}} = \frac{1}{8}$.

As $B' = B/8$, $\therefore\ \frac{r^2}{(r^2 + x^2)^{3/2}} = \frac{1}{8r}$

$8r^3 = (r^2 + x^2)^{3/2}$ or, $2r = (r^2 + x^2)^{1/2}$

or, $4r^2 = r^2 + x^2$ or, $x = \sqrt{3}r$.

15. **(b)** : $I = \frac{2rH}{n\mu_0}\tan\theta$.

The sensitivity can be increased (*i.e.* more deflection for the given current) if $\frac{2rH}{n\mu_0}$ is decreased. It will be so if n is increased, r is decreased and H is decreased.

16. **(c)** : Light does not travel with infinite speed.

17. **(b)** : $m = \frac{h_2}{h_1} = \frac{-v}{u}$. Here, image is virtual.

$\therefore\ h_2 = \frac{1}{n}h_1$

$\therefore\ \frac{1}{n}\frac{h_1}{h_1} = \frac{-v}{u}$ or, $v = \frac{-u}{n}$ and

f for convex mirror is positive

$\therefore\ \frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ or $\frac{1}{f} = \frac{1}{u} - \frac{1}{u/n} = \frac{1-n}{u}$

or, $u = (1-n)f$ or, $-u = (n-1)f$.

18. **(b)** : $\mu = \frac{\text{velocity of light in air}(c)}{\text{velocity of light in water}(v)} = \frac{\upsilon\lambda}{\upsilon\lambda'} = \frac{\lambda}{\lambda'} = \frac{4}{3}$

As, $d = \frac{\lambda}{\theta} = \frac{\lambda'}{\theta'}$, $\therefore\ \frac{\lambda'}{\lambda} = \frac{\theta'}{\theta} = \frac{3}{4}$

or, $\theta' = \frac{3}{4}\theta = \frac{3}{4}\times 0.2° = 0.15°$.

19. **(d)** : Dispersive power of lens ω is

$= \frac{f_R - f_B}{\sqrt{f_R . f_B}} = \frac{100.9 - 99.5}{\sqrt{100.9\times 99.5}} = 0.013$. $\therefore\ \omega \approx 0.01$

20. **(a)** : $\lambda = \frac{h}{mv}$ or, $v = \frac{h}{\lambda m}$

$E = \frac{1}{2}mv^2 = \frac{1}{2}m\frac{h^2}{\lambda^2 m^2} = \frac{1}{2}\frac{h^2}{\lambda^2 m}$

i.e. $E \propto 1/m$.

$m_\alpha > m_p > m_e$. $\therefore$ $E_1 > E_3 > E_2$.

21. (d) : $\lambda = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2m\times(3/2)kT}} = \frac{h}{\sqrt{3mkT}}$

i.e. $\lambda \propto 1/\sqrt{T}$; so

$$\lambda_2 = \lambda_1\sqrt{\frac{T_1}{T_2}} = \lambda\sqrt{\frac{273+27}{273+927}} = \frac{\lambda}{2}.$$

22. (d) : ${}_6C^{11} \rightarrow {}_5B^{11} + \beta^+ + {}_ZX^A$

Conservation of mass number:

$11 = 11 + 0 + A$, $\therefore$ $A = 0$

Conservation of charge number:

$6 = 5 + 1 + Z$, $\therefore$ $Z = 0$

Hence X stands for neutrino.

23. (a) : $\beta = \frac{I_C}{I_B}$ or, $I_C = \beta I_B = 60 I_B$

Since, $I_E = I_B + I_C$.

$\therefore$ $I_E = I_B + 60I_B = 61I_B$

$$I_B = \frac{I_E}{61} = \frac{6.6\times10^{-3}}{61} = 0.108 \text{ mA}.$$

24. (b) : To detect the intensity of light, we use photodiode in reverse biased.

25. (d) : $\overline{A} + B = \overline{1} + 1 = 0 + 1 = 1 = A$ or B.

26. (c) : Velocity = speed + direction. If velocity changes, the direction of motion of body may change, the speed of body may or may not change. The change in velocity must produce acceleration. If speed changes, then velocity of body must change and hence there must be an acceleration.

27. (a) : $v_0 = \sqrt{v_1^2 + v_2^2 + 2v_1v_2\cos\theta}$

If θ has any value between 0° to 180°, then $\cos\theta$ will be positive, zero or negative.

28. (d) : Take horizontal motion from O to W, we have

$s = ut$ or, $\frac{\sqrt{3}}{2} = u\cos60°\times t = u\frac{1}{2}t$

or, $t = \sqrt{3}/u$ ... (i)

Taking vertical motion from O to W, we have

$s = ut - \frac{1}{2}gt^2$. If $s = 1.0$ m,

$$1.0 = u\sin60°\times\frac{\sqrt{3}}{u} - \frac{1}{2}\times10\times\frac{3}{u^2}$$

or, $1 = \frac{\sqrt{3}}{2}\times\sqrt{3} - \frac{15}{u^2} = \frac{3}{2} - \frac{15}{u^2}$

or, $\frac{15}{u^2} = \frac{3}{2} - 1 = \frac{1}{2}$ or, $u^2 = 30$ or, $u = \sqrt{30}$

If $s = 1.5$ m, then

$$1.5 = u\sin60°\times\frac{\sqrt{3}}{u} - \frac{1}{2}\times10\times\frac{3}{u^2} = \frac{3}{2} - \frac{15}{u^2}$$

or, $\frac{15}{u^2} = 0$ or, $u = \infty$

So the ball will enter the window with all velocities greater than 5 m/s upto ∞.

29. (c) : In a non uniform field, $\Sigma F \neq 0$. When dipole is aligned with field, $\Sigma\tau = 0$ and when dipole is not aligned, $\Sigma\tau \neq 0$.

30. (d) : A reference frame attached to earth is not inertial because rotation of earth around its axis as also around the sun are not uniform.

31. (d) : The speed with which the body hits the ground is $v = \sqrt{u^2 + g^2t^2}$. Clearly, v depends on u and $v > u$.

32. (a) : According to theorem of perpendicular axes

$I = I_1 + I_2$ and $I = I_3 + I_4$

As $I_2 = I_3$, $\therefore$ $I = I_1 + I_3$.

33. (b) : $\frac{-GMm_e}{r^2} + \frac{1}{2}\frac{mv^2}{r} = 0$

34. (d) : The angle of contact at the free liquid surface inside the capillary tube will change in such a way so that the vertical component of the surface tension forces just balance the weight of liquid column.

35. (b) : The process must be cyclic. Therefore, final temperature = initial temperature. As internal energy of an ideal gas is a function of temperature alone, therefore, final internal energy = initial internal energy.

36. (b) : A motion will be simple harmonic if acceleration $\propto -y$

(i) As $y = \sin2\omega t$, $v = \frac{dy}{dt} = 2\omega\cos2\omega t$

Acceleration $= \frac{dv}{dt} = -4\omega^2\sin2\omega t = -4\omega^2 y$

So, $y = \sin2\omega t$ represents simple harmonic motion.

(ii) $y = \sin\omega t + 2\cos\omega t$

$$v = \frac{dy}{dt} = \omega\cos\omega t - 2\omega\sin\omega t$$

Acceleration $= \frac{dv}{dt} = -\omega^2\sin\omega t - 2\omega^2\cos\omega t$

$= -\omega^2(\sin\omega t + 2\cos\omega t) = -\omega^2 y$.

$\therefore$ The given function represents simple harmonic motion.

The remaining two functions do not represent simple harmonic motion.

37. (d) : Maximum speed of any point on the string

$= a\omega = v/10$

or, $a2\pi f = v/10$

$$f = \frac{v}{20\pi a} = \frac{10}{20\pi\times 10^{-3}} = \frac{10^2}{2\pi}\text{ Hz.}$$

$$\lambda = \frac{v}{f} = \frac{10\times 2\pi}{10^2} = 2\pi\times 10^{-2}\text{ m.}$$

38. (a) : (a) Initial charge = $(KC_0)E$

Final charge = C_0E

Charge that flows through the cell

$= KC_0E - C_0E = EC_0(K-1)$

(b) Initial energy = KC_0E^2

Final energy = C_0E^2

$\therefore$ Energy absorbed by the cell

$= KC_0E^2 - C_0E^2 = C_0E^2(K-1)$

(c) Work done in taking out the slab

$$= \frac{1}{2}KC_0E^2 - \frac{1}{2}C_0E^2 = \frac{1}{2}C_0E^2(K-1).$$

39. (d) : $R_1 = \frac{V^2}{P_1} = \frac{V^2}{25}$ and $R_2 = \frac{V^2}{100}$

$$\text{Current, } I = \frac{V}{R_1+R_2} = \frac{V}{(V^2/25)+(V^2/100)} = \frac{20}{V}$$

$$\text{Power in 25 W bulb} = I^2R_1 = \left(\frac{20}{V}\right)^2\times\frac{V^2}{25} = 16\text{ W}$$

$$\text{Power in 100 W bulb} = I^2R_2 = \left(\frac{20}{V}\right)^2\times\frac{V^2}{100} = 4\text{ W}.$$

40. (a)

41. (d) : When a clockwise current carrying coil is placed in a perpendicular uniform magnetic field, there is no net force on the ring and ring will tend to expand as the direction of force on every part of the ring is acting outwards.

42. (b) : The liquid level rises in case of paramagnetic and ferromagnetic liquids, as they tend to move from weaker parts to stronger parts of the field.

43. (d) : As $e = d\phi/dt$, therefore, if $\phi = 0$, $e = 0$, However, e can be zero, when ϕ = constant $\neq 0$. If $e \neq 0$, $d\phi/dt \neq 0$, ϕ may not be zero.

44. (a) : The equation 1 and 3 are related to source of electric field and equation 2 with source of magnetic field.

45. (a) : When light of different colours move through water, they have different wavelengths, different velocities and different amplitude.

46. (d) : For light travelling from bird (rarer medium) to fish (denser medium), $\mu_1 = 1$ and $\mu_2 = \mu$ – refractive index of water.

Let $u = -x$.

As $\frac{u}{v} = \frac{\mu_1}{\mu_2} = \frac{1}{\mu}$, $\therefore$ $v = \mu x$

As $\mu > 1$, $\therefore$ $v > x$

Also, speed of bird = dx/dt

$$\text{Apparent speed of bird} = \mu\frac{dx}{dt} > \frac{dx}{dt}.$$

47. (a) : According to quantum nature of light, the light travels as packets of energy called photons. Each photon is of definite energy which does not change with the change in intensity of light. Using this concept all the alternatives (1), (2) and (3) can be understood easily.

$$\textbf{48. (b) :}\ T_n = \frac{2\pi r_n}{v_n} \propto \frac{r_n}{v_n} \propto \frac{n^2}{1/n} \propto n^3.$$

Here, $\frac{8}{1} = \left(\frac{n_1}{n_2}\right)^2$ or, $\frac{n_1}{n_2} = 2$. $\therefore$ $n_1 = 2n_2$.

49. (d) : Semiconducting devices are current dependent and temperature dependent as electrical conductivity of semiconductor increases with increase in temperature.

50. (c) : The width of depletion zone of an unbiased *p-n* junction is dependent of densities of the dopants. The electric field in the zone is produced due to ionized dopant atoms.

Contd. from page no. 26

(b) The maximum energy of the photon in the radiation is given by $E = h\nu_{max} = \dfrac{hc}{\lambda_{min}}$

Now $\lambda_{min} = 0.45$ Å $= 0.45\times10^{-10}$ m

$$\therefore\ E = \frac{6.6\times10^{-34}\times3\times10^{8}}{0.45\times10^{-10}}\ \text{J}$$

$$\text{or } E = \frac{6.6\times10^{-34}\times3\times10^{8}}{0.45\times10^{-10}\times1.6\times10^{-19}}\ \text{eV}$$

$= 27.6 \times 10^3$ eV = 27.6 keV

The accelerating voltage for electrons to produce X-rays in the X-ray tube is 27.6 keV.

(c) For a semiconductor, the valence band is totally filled and the conduction band is empty at absolute zero temperature. But the forbidden gap between conduction band and valence band is quite small for semiconductor. For example, it is only 0.72 eV for germanium and 1.1 eV for silicon. Near absolute zero, the electrons cannot cross even this small forbidden gap. But as the temperature is increased, more and more number of electrons in the valence band acquire thermal energy to cross the forbidden gap and move to the conduction band where they can move under the action of even small electric field. Hence the conductivity of semiconductor increases with increase in temperature.

6. **(a)** Heat absorbed by the system in going from state A to state B.

= 9.35 calorie = 9.35 × 4.19 J = 39.18 J

Also, total work done on the system in going from state A to state B = 22.3 J.

∴ Net work done by the system in the process

= (39.18 – 22.3) J = 16.88 J ≃ 16.9 J.

(b) The land is more quickly heated or cooled than sea-water because specific heat of land is less than that of sea-water. So during the day time the land becomes more heated and lighter than the air over sea-water. As a result, lighter hot air on land rises up, and to maintain an equilibrium in pressure, cooler air over the sea flows towards the land. The flow of air from the sea to the land during day time is known as sea-breeze. Thus the higher specific heat of water causes the sea-breeze.

7. **(a)** The potenital energy gained by the bob of the pendulum in the position $PR = mgh$

where m is the mass of the bob. Gain in potential energy of the bob = $m \times 9.8 \times 2 = 19.6\ m$.

Since 3% of the initial energy is dissipated against air resistance the energy possessed by bob when passing across point O is $= 19.6\ m\times\dfrac{97}{100} = 19.012\ m$.

Let v be the speed of the bob when it is at the point O.

Then we have $\dfrac{1}{2}mv^2 = 19.012\ m$; $v^2 = 19.012 \times 2$

$v = \sqrt{19.012\times2} = 6.166\ \text{ms}^{-1}$.

(b) The rise in temperature of water is

$\Delta\theta = [(41 \pm 0.1) - (16 \pm 0.5)]$°C

$= [(41 - 16) \pm (0.1 + 0.5)]$°C $= 25 \pm 0.6$°C

The logic of this again becomes clear if we note that. Final temperature is anywhere between (40.9 and 41.1)°C and initial temperature is anywhere between (15.5 and 16.5). The rise is therefore between (40.9 – 16.5) and (41.1 – 15.5) or between 24.4°C and 25.6°C. This is just the range indicated by the above equation of the temperature rise.

8. **(a)** Given $y = -\dfrac{2}{3}t^2 + 16t + 2$.

Comparing it with $s = ut + \dfrac{1}{2}at^2$, we have

$u = 16\ \text{ms}^{-1}$ and $\dfrac{a}{2} = -\dfrac{2}{3}$ or $a = -\dfrac{4}{3}\ \text{ms}^{-2}$.

For a body to come to rest, the final velocity $v = 0$,

using these values $\Rightarrow v = u + at \Rightarrow 0 = 16 - \dfrac{4}{3}t$

or $t = 12$ s.

(b) The co-efficient of friction and hence the frictional force between the surfaces of same material is greater than that in case of dissimilar material surfaces. So to reduce the frictional force, machine bearings are made of one metal while their rotating shafts are made of a different material.

(c) $\dfrac{1}{\lambda} = R\left[\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right]$

for Balmer series $n_1 = 2$

for longest wavelength $n_2 = 3$

$$\frac{1}{\lambda} = R\left[\frac{1}{4} - \frac{1}{9}\right] = \frac{5R}{36}$$

$$\lambda = \frac{36}{5}\times\frac{1}{R} = \frac{36}{5}\times910\ \text{Å} = 6552\ \text{Å}\quad\left(\because \frac{1}{R} = 910\ \text{Å}\right)$$

for shortest wavelength, $n_2 = \infty$

$$\frac{1}{\lambda} = R\left(\frac{1}{4}\right)$$

$$\Rightarrow \lambda = \frac{4}{R} = 4\times910\ \text{Å} = 3640\ \text{Å}.$$

9. **(a)** Let i be the current drawn. The total power drawn from the d.c. source is then εi out of which a part i^2r gets dissipated (as heat) in the internal resistance of the source. The power output, P, of the source is then $P = \varepsilon i - i^2r$

We want P to be a maximum. For this we must have

$\frac{dP}{di} = 0$. Now, $\frac{dP}{di} = \varepsilon \times 1 - r \times 2i = \varepsilon - 2ri$

Thus $\frac{dP}{di} = 0$ when $i = \frac{\varepsilon}{2r}$

Thus the power output of the source is maximum when the current drawn is $\varepsilon/2r$.

(b) If v is the drift speed of electrons, the current I is

$$I = Anev \qquad \text{...(i)}$$

where n is number of free electrons per unit volume. To obtain n we note that it is equal to number of atoms per unit volume because there is one free electron per atom. The number of atoms per unit volume is obtained from the fact that Avogadro number of atoms constitutes one-gram mol. of material. Therefore

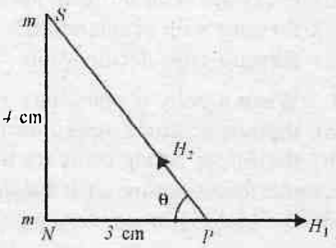
$$n\left[\frac{M}{\rho}\right] = N \text{ or } n = \frac{N\rho}{M} = \frac{6.02\times10^{23}\times8.92\times10^{3}}{63.5\times10^{-3}}$$

$$= 8.5\times 10^{28} \text{ atom/m}^3 \qquad \text{...(ii)}$$

From equations (i) and (ii)

$$v = \frac{5}{3\times10^{-6}\times1.6\times10^{-19}\times8.5\times10^{28}} = 1.2\times10^{-4}\text{ ms}^{-1}.$$

(c) Let the magnet NS of pole strength m be held vertically with its north pole N resting on a horizontal table. P is a point on the table such that PN = 3 cm (figure).



The intensity at P due to the N-pole of the magnet is given by $H_1 = m/3^2$ in the direction as shown in the figure.

The intensity at P due to the S-pole of the magnet is

Now, $PS^2 = PN^2 + NS^2 = 3^2 + 4^2 = 25$

$\therefore\ H_2 = m/25$ along PS

The horizontal component of H_2 is $H_2 \cos\theta = \frac{m}{25}\times\frac{3}{5}$

[as $\cos\theta = \frac{PN}{PS} = \frac{3}{5}$]

For P to be a neutral point, we must have

$H_1 - H_2 \cos\theta = H$

[H = Horizontal component of earth's magnetic field]

$$\therefore\ \frac{m}{9} - \frac{m}{25}\times\frac{3}{5} = 0.2 \qquad [\because H = 0.2]$$

$$\text{or}\quad m\left(\frac{1}{9} - \frac{3}{125}\right) = 0.2 \quad \text{or} \quad m = \frac{225}{98} \text{ unit}$$

Therefore, the moment of the magnet is

M = pole strength × length of the magnet

$$= \frac{225}{98}\times 4 = 9.2 \text{ unit.}$$

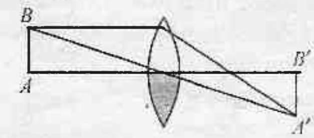
10. (a) The speed of sound in a gaseous medium is inversely proportional to the square root of its density *i.e.* $v \propto \sqrt{1/\rho}$. Now, the density of water-vapour is less than air and so the density of moist air (air mixed with water vapour) is less than the density of dry air. Hence the speed of sound is greater in moist air than in dry air. But the density of hydrogen is less than the density of water vapour and hence the density of moist hydrogen is more than the density of dry hydrogen. So the speed of sound in moist hydrogen will be less than in dry hydrogen.

(b) $\mu_{glass} = \frac{\text{speed of light in vacuum}}{\text{speed of light in glass}}$

or $1.5 = \frac{3\times10^8\text{ ms}^{-1}}{\text{speed of light in glass}}$

$\therefore$ Speed of light in glass $= \frac{3\times10^8}{1.5}\text{ ms}^{-1} = 2\times10^8\text{ ms}^{-1}$.

(c) Yes. The image formed will still be of full size. The ray diagram showing the formation of image is as shown in figure. It may be pointed out that the intensity of the image will be lesser, when the lower half of the lens is painted black. It is because, light gathering power of a lens depends upon its diameter.



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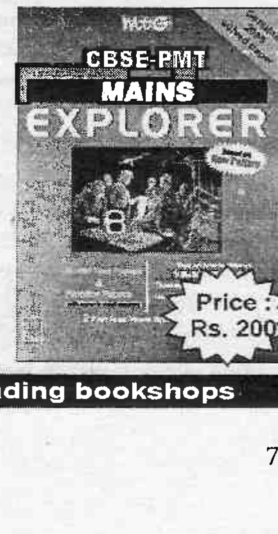
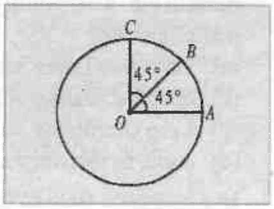


Model Test Paper CBSE-PMT 2008

Full Length

PHYSICS

1. Find the resultant of three vectors $\overrightarrow{OA}, \overrightarrow{OB}$ and $\overrightarrow{OC}$ shown in the following figure. Radius of the circle is R.

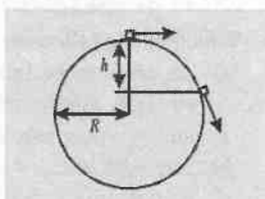


(a) $2R$
(b) $R(1+\sqrt{2})$
(c) $R\sqrt{2}$
(d) $R(\sqrt{2}-1)$

2. Radius of the curved road on national highway is R. Width of the road is b. The outer edge of the road is raised by h with respect to inner edge so that a car with velocity v can pass safe over it. The value of h is

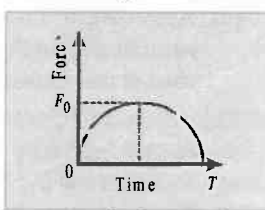
(a) $\frac{v^2 b}{Rg}$ (b) $\frac{v}{Rgb}$ (c) $\frac{v^2 R}{g}$ (d) $\frac{v^2 b}{R}$

3. A particle originally at rest at the highest point of a smooth vertical circle is slightly displaced. It will leave the circle at a vertical distance h below the highest point such that



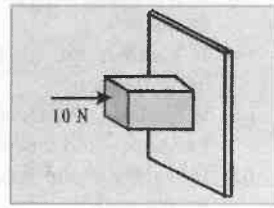
(a) $h = R$ (b) $h = \frac{R}{3}$ (c) $h = \frac{R}{2}$ (d) $h = \frac{2R}{3}$

4. A particle of mass m, initially at rest, is acted upon by a variable force F for a brief interval of time T. It begins to move with a velocity u after the force stops acting. F is shown in the graph as a function of time. The curve is a semicircle



(a) $u = \frac{\pi F_0^2}{2m}$
(b) $u = \frac{\pi T^2}{8m}$
(c) $u = \frac{\pi F_0 T}{4m}$
(d) $u = \frac{F_0 T}{2m}$

5. A horizontal force of 10 N is necessary to just hold a block stationary against a wall. The coefficient of friction between the block and the wall is 0.2. the weight of the block is



(a) 2 N (b) 20 N (c) 50 N (d) 100 N

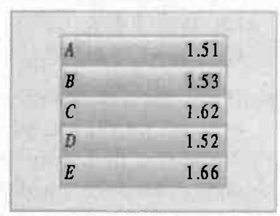
6. A block is kept on an inclined plane of inclination 0 of length l. The velocity of particle at the bottom of incline is (the coefficient of friction is μ)

(a) $\sqrt{2gl(\mu\cos\theta - \sin\theta)}$ (b) $\sqrt{2gl(\sin\theta - \mu\cos\theta)}$
(c) $\sqrt{2gl(\sin\theta + \mu\cos\theta)}$ (d) $\sqrt{2gl(\cos\theta + \mu\sin\theta)}$

7. A concave mirror is used to focus the image of a flower on a nearby well 120 cm from the flower. If a lateral magnification of 16 is desired, the distance of the flower from the mirror should be

(a) 8 cm (b) 12 cm (c) 80 cm (d) 120 cm

8. Immiscible transparent liquids A, B, C, D and E are placed in a rectangular container of glass with the liquids making layers according to their densities. The refractive index of the liquids are shown in the adjoining diagram. The container is illuminated from the side and a small piece of glass having refractive index 1.61 is gently dropped into the liquid layer. The glass piece as it descends downwards will not be visible in



(a) Liquid A and B only (b) Liquid C only
(c) Liquid D and E only (d) Liquid A, B, D and E

9. On a glass plate a light wave is incident at an angle of 60°. If the reflected and the refracted waves are mutually perpendicular, the refractive index of material is

(a) $\frac{\sqrt{3}}{2}$ (b) $\sqrt{3}$ (c) $\frac{3}{2}$ (d) $\frac{1}{\sqrt{3}}$

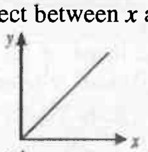
10. The wavelength of sodium light in air is 5890 Å. The velocity of light in air is 3×10^8 ms^{-1}. The wavelength of light in a glass of refractive index 1.6 would be close to
(a) 5890 Å (b) 3681 Å (c) 9424 Å (d) 15078 Å

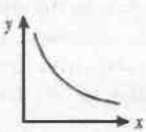
11. Which of the following statements is correct?
(a) In vacuum, the speed of light depends upon frequency.
(b) In vacuum, the speed of light does not depend upon frequency.
(c) In vacuum, the speed of light is independent of frequency and wavelength.
(d) In vacuum, the speed of light depends upon wavelength.

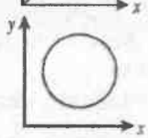
12. Glass has refractive index μ with respect to air and the critical angle for a ray of light going from glass to air is θ. If a ray of light is incident from air on the glass with angle of incidence θ, the corresponding angle of refraction is
(a) $\sin^{-1}\left(\frac{1}{\sqrt{\mu}}\right)$ (b) 90°
(c) $\sin^{-1}\left(\frac{1}{\mu^2}\right)$ (d) $\sin^{-1}\left(\frac{1}{\mu}\right)$

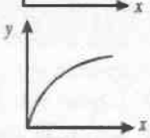
13. Two lenses have focal lengths f_1 and f_2 and their dispersive powers are ω_1 and ω_2 respectively. They will together form an achromatic combination if
(a) $\omega_1 f_1 = \omega_2 f_2$ (b) $\omega_1 f_2 + \omega_2 f_1 = 0$
(c) $\omega_1 + f_1 = \omega_2 + f_2$ (d) $\omega_1 - f_1 = \omega_2 - f_2$

14. If x is the distance of an object from the focus of a concave mirror and y is the distance of image from the focus, then which of the following graphs is correct between x and y ?

(a) 

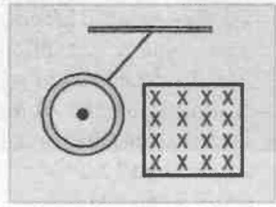
(b) 

(c) 

(d) 

15. If a particle of charge 10^{-12} coulomb moving along the x-direction with a velocity 10^5 m/s experiences a force of 10^{-10} newton in y-direction due to magnetic field, then the minimum magnetic field is
(a) 6.25×10^3 tesla in z- direction
(b) 10^{-15} tesla in z- direction
(c) 6.25×10^{-3} tesla in z- direction
(d) 10^{-3} tesla in z- direction

16. A metallic ring connected to a rod oscillates freely like a pendulum. If now a magnetic field is applied in horizontal direction so that the pendulum now swings through the field, the pendulum will



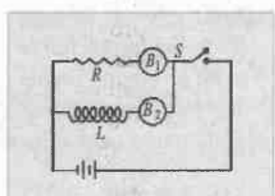
(a) keep oscillating with the old time period
(b) keep oscillating with a smaller time period
(c) keep oscillating with a larger time period
(d) come to rest very soon

17. In a magnetic field of 0.05 T, area of a coil changes from 101 cm^2 to 100 cm^2 without changing the resistance which is 2 Ω. The amount of charge that flow during this period is
(a) 2.5×10^{-6} coulomb (b) 2×10^{-6} coulomb
(c) 10^{-6} coulomb (d) 8×10^{-6} coulomb

18. A generator produces a voltage that is given by $V = 240\sin 120t$, where t is in seconds. The frequency and rms voltage are
(a) 60 Hz and 240 V (b) 19 Hz and 120 V
(c) 19 Hz and 170 V (d) 754 Hz and 70 V

19. Which of the following is wrong statement?
(a) An emf can be induced between the ends of a straight conductor by moving it through a uniform magnetic field.
(b) The self induced emf produced by changing current in a coil always tends to decrease the current.
(c) Inserting an iron core in a coil increases its coefficient of self induction.
(d) According to Lenz's law the direction of the induced current is such that it opposes the flux change that causes it.

20. The adjoining figure shows two bulbs B_1 and B_2 resistor R and an inductor L. When the switch S is turned off



(a) both B_1 and B_2 die out promptly
(b) both B_1 and B_2 die out with some delay
(c) B_1 dies out promptly but B_2 with some delay
(d) B_2 dies out promptly but B_1 with some delay

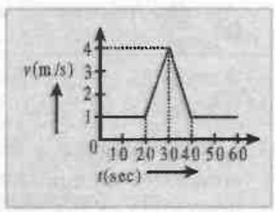
21. The focal lengths of the objective and the eye-piece of a compound microscope are 2.0 cm and 3.0 cm respectively. The distance between the objective and the eye-piece is 15.0 cm. The final image formed by the eye-piece is at infinity. The two lenses are thin. The distances in cm of the object and the image produced by the objective measured from the objective lens are respectively

(a) 2.4 and 12.0 (b) 2.4 and 15.0
(c) 2.3 and 12.0 (d) 2.3 and 3.0

22. A hollow double concave lens is made of very thin transparent material. It can be filled with air or either of two liquids L_1 and L_2 having refractive indices n_1 and n_2 respectively ($n_2 > n_1 > 1$). The lens will diverge a parallel beam of light if it is filled with

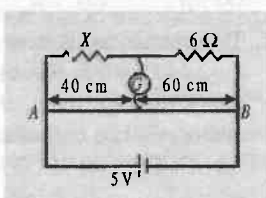
(a) Air and placed in air
(b) Air and immersed in L_1
(c) L_1 and immersed in L_2
(d) L_2 and immersed in L_1

23. Velocity time (v-t) graph for a moving object is shown in the figure. Total displacement of the object during the time interval when there is non-zero acceleration and retardation is



(a) 60 m (b) 50 m (c) 30 m (d) 40 m

24. In the circuit shown, a meter bridge is in its balanced state. The meter bridge wire has a resistance 0.1 ohm/cm. The value of unknown resistance X and the current drawn from the battery of negligible resistance is



(a) 6 Ω, 5 amp (b) 10 Ω, 0.1 amp
(c) 4 Ω, 1.0 amp (d) 12 Ω, 0.5 amp

25. Two ions having masses in the ratio 1 : 1 and charges 1 : 2 are projected into uniform magnetic field perpendicular to the field with speeds in the ratio 2 : 3. The ratio of the radii of circular paths along which the two particles move is

(a) 4 : 3 (b) 2 : 3 (c) 3 : 1 (d) 1 : 4

26. A straight wire carrying a current i_1 amp runs along the axis of circular current i_2 amp. Then the force of interaction between the two current carrying conductors is

(a) ∞ (b) zero
(c) $\frac{\mu_0}{4\pi}\frac{2i_1i_2}{r}$ N/m (d) $\frac{2i_1i_2}{r}$ N/m

27. A solenoid has 2000 turns wound over a length of 0.30 metre. The area of its cross-section is 1.2×10^{-3} m^2. Around its central section, a coil of 300 turns is wound. If an initial current of 2 A in the solenoid is reversed in 0.25 sec, then the emf induced in the coil is

(a) 6×10^{-4} V (b) 4.8×10^{-3} V
(c) 6×10^{-2} V (d) 48 mV

28. A closely wound coil of 100 turns and area of cross-section 1 cm^2 has a coefficient of self-induction 1 mH. The magnetic induction in the centre of the core of the coil when a current of 2 A flows in it, will be

(a) 0.022 Wb m^{-2} (b) 0.4 Wb m^{-2}
(c) 0.8 Wb m^{-2} (d) 1 Wb m^{-2}

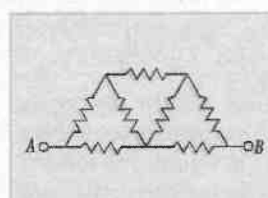
29. The coil of dynamo is rotating in a magnetic field. The developed induced emf changes and the number of magnetic lines of force also changes. Which of the following condition is correct?

(a) Lines of force minimum but induced emf is zero.
(b) Lines of force maximum but induced emf is zero.
(c) Lines of force maximum but induced emf is not zero.
(d) Lines of force maximum but induced emf is also maximum.

30. An alternating current is given by the equation $i = i_1 \cos \omega t + i_2 \sin \omega t$. The r.m.s. current is given by

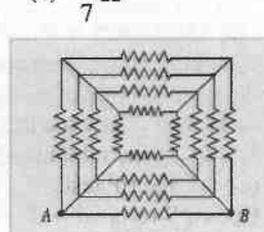
(a) $\frac{1}{\sqrt{2}}(i_1 + i_2)$ (b) $\frac{1}{\sqrt{2}}(i_1 + i_2)^2$
(c) $\frac{1}{\sqrt{2}}(i_1^2 + i_2^2)^{1/2}$ (d) $\frac{1}{2}(i_1^2 + i_2^2)^{1/2}$

31. Seven resistors, each of 1 Ω, are connected as shown in the figure. The effective resistance between A and B is



(a) $\frac{4}{3}$ Ω (b) $\frac{3}{2}$ Ω
(c) 7 Ω (d) $\frac{8}{7}$ Ω

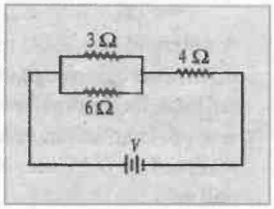
32. Sixteen resistors each of resistance 16 Ω are connected in the circuit as shown. The net resistance between AB is



(a) 1 Ω (b) 2 Ω

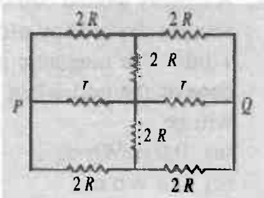
(c) $3\,\Omega$ (d) $4\,\Omega$

33. If the current flowing through the $3\,\Omega$ resistor is 0.8 A, the potential drop across the $4\,\Omega$ resistor is



(a) $1.6V$ (b) $2.4V$
(c) $4.8V$ (d) $9.6V$

34. The effective resistance between points P and Q of the electrical circuit shown in figure is



(a) $\dfrac{2Rr}{R+r}$

(b) $\dfrac{8R(R+r)}{3R+r}$

(c) $2r+4R$

(d) $\dfrac{5R}{2}+2r$

35. The speed of a projectile u reduces by 50% on reaching maximum height. The range on the horizontal plane is

(a) $\dfrac{2u^2}{3g}$ (b) $\dfrac{u^2}{g}$ (c) $\dfrac{\sqrt{3}u^2}{2g}$ (d) $\dfrac{3u^2}{g}$

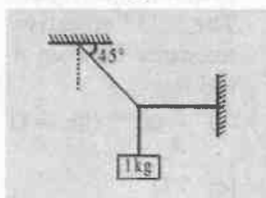
36. One second after the projection, a stone moves at an angle of 45° with the horizontal. Two seconds from the start, it is travelling horizontally. Its angle of projection with the horizontal is (given $g = 10\ \text{ms}^{-2}$)
(a) 60° (b) $\tan^{-1}(4)$
(c) $\tan^{-1}(3)$ (d) $\tan^{-1}(2)$

37. A projectile can have the same range R for the two angles of projection. If t_1 and t_2 be the time of flight in two cases, then what is the product of two times of flight ?

(a) $t_1t_2 \propto R$ (b) $t_1t_2 \propto R^2$

(c) $t_1t_2 \propto \dfrac{1}{R}$ (d) $t_1t_2 \propto \dfrac{1}{R^2}$

38. A weight of 1kg is suspended as shown in figure. The tension in the horizontal cord will be



(a) 0.5 kg wt
(b) 52 kg wt
(c) 1.0 kg wt (d) 2 kg wt

39. A block of mass M is pulled along a horizontal frictionless surface by a rope of mass m by applying a force P at one end of the rope. The force which the rope exerts on the block is

(a) $\dfrac{P}{M-m}$ (b) $\dfrac{PM}{M+m}$

(c) $\dfrac{Pm}{M+m}$ (d) $Pm\,(M+m)$

40. The work done in increasing the voltage across the plates of a capacitor from 5 V to 10 V is W. The work done in increasing the voltage from 10 V to 15 V will be

(a) W (b) $\dfrac{4W}{3}$ (c) $\dfrac{5W}{3}$ (d) $2W$

41. The radii of two spheres forming a spherical condenser are 0.5 m and 0.6 m. If a medium of dielectric constant 6 is completely filled in between, the capacity of the condenser will be
(a) 3.3×10^{-10} F (b) 2×10^{-9} F
(c) 2 F (d) 18 F

42. A charge Q is divided into two parts and the two parts are separated by a certain distance. The force between them will be maximum if one of the charges is

(a) $\dfrac{Q}{2}$ (b) $\dfrac{Q}{3}$

(c) $\dfrac{Q}{4}$ (d) none of these

43. Electric charges q, q and $-2q$ are placed at the three corners of an equilateral triangle of side l. The magnitude of the electric dipole moment of the system is
(a) ql (b) $2ql$ (c) $\sqrt{3}ql$ (d) $4ql$

44. Two circular coils have number of turns in the ratio 1 : 2 and radii in the ratio 2 : 1. If the same current flows through them, the magnetic fields at their centres will be in the ratio
(a) 1 : 1 (b) 1 : 2 (c) 2 : 1 (d) 1 : 4

45. Force between two long straight parallel current-carrying wires is F. If the current in one of them is doubled, the force between them will be
(a) $2F$ (b) $\sqrt{2}F$ (c) $2\sqrt{2}F$ (d) $4F$

46. If a current $I = I_0 \sin\left(\omega t - \dfrac{\pi}{2}\right)$ flows in a circuit across which an alternating potential $E = E_0 \sin \omega t$ has been applied, then the power consumed in the circuit is

(a) $\dfrac{E_0I_0}{\sqrt{2}}$ (b) $\dfrac{E_0I_0}{2}$ (c) $\dfrac{EI}{\sqrt{2}}$ (d) zero

47. A current of 2 A flowing through a coil of 100 turns gives rise to a magnetic flux of 5×10^{-5} Wb per turn. The magnetic energy associated with the coil is
(a) 5 J (b) 0.5 J (c) 0.05 J (d) 0.005 J

48. A vessel of depth d is half filled with a liquid of refractive index μ_1 and the other half is filled with a liquid of refractive index μ_2. The apparent depth of the vessel, when looked at normally, is

(a) $d(\mu_1 + \mu_2)$ (b) $d\left(\frac{1}{\mu_1}+\frac{1}{\mu_2}\right)$

(c) $\frac{d}{2}(\mu_1+\mu_2)$ (d) $\frac{d}{2}\left(\frac{1}{\mu_1}+\frac{1}{\mu_2}\right)$

49. A man standing in a swimming pool looks at a stone lying at the bottom. The depth of the swimming pool is h. At what distance from the surface of water is the image of the stone formed Line of vision is normal. Refractive index of water is n

(a) $\frac{h}{n}$ (b) $\frac{n}{h}$ (c) h (d) hn

50. For two positions of a lens, the images are obtained on a fixed screen. If the size of object is 2 cm and the size of diminished image is 0.5 cm, the size of the other image will be

(a) 1 cm (b) 4 cm (c) 8 cm (d) 16 cm

CHEMISTRY

51. The minimum value of n for which g subshell is possible is

(a) 6 (b) 5 (c) 4 (d) 3

52. The charge to mass ratio of α particles is approximately .... the charge to mass ratio of protons

(a) twice (b) half
(c) four times (d) six times

53. The number of spherical nodes in $3p$ subshell is

(a) three (b) two (c) one (d) zero

54. Which of the following sets of elements would have the lowest first ionisation energy (IE_1)?

(a) Mg (b) Rb (c) Li (d) Ca

55. Beryllium has diagonal relationship with

(a) Li (b) B (c) Na (d) Al

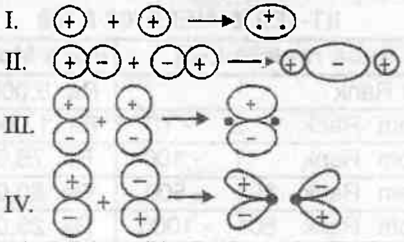
56. The size of the following species increases in the order

(a) $Mg^{2+} < Na^+ < F^- < Al$ (b) $F^- < Al < Na^+ < Mg^{2+}$
(c) $Al < Mg^{2+} < F^- < Na^+$ (d) $Na^+ < Al < F^- < Mg^{2+}$

57. The inability of N to form NCl_5 is due to

(a) non-availability of vacant d orbital in valence shell of N
(b) high ionisation energy of N
(c) low electron affinity of N
(d) small size of N atom.

58. Which of the following overlap of orbitals is/are incorrect ?



(a) I, III (b) II, III (c) III, IV (d) I, IV

59. BCl_3 is a planar molecule because in this molecule boron is

(a) sp^3 hybridised (b) sp^2 hybridised
(c) sp hybridised (d) unhybridised

60. Dehydration of sucrose, $C_{12}H_{22}O_{11}$ by concentrated H_2SO_4 gives purest form of carbon. The amount of carbon which can be obtained from 34.2 g of sucrose is

(a) 14.4 g (b) 12 g atom
(c) 3.2 g atom (d) 14.4 g atom

61. In the reaction, $2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI$, the equivalent mass of $2Na_2S_2O_3$(Mol. Mass = M) is

(a) M (b) $M/2$ (c) $M/3$ (d) $M/4$

62. An endothermic reaction, $A \rightarrow B$, has an activation energy as x kJ mol^{-1} of A. If energy change of the reaction is y kJ, the activation energy of reverse reaction is

(a) $-x$ (b) $x-y$ (c) $x+y$ (d) $y-x$

63. The rate constant for a first order reaction is 1×10^{-2} s^{-1}. The concentration of the reactants would be reduced from 1 mole to 0.25 mole in

(a) 10^2 sec (b) 69.3 sec
(c) 0.5×10^2 sec (d) 138.6 sec

64. Ratio $t_{7/8}/t_{1/2}$ for a first order reaction would be equal to

(a) 7 (b) 2 (c) 8 (d) 3

65. Vapour density of PCl_5 is 104.16 but when heated to 230°C its vapour density is reduced to 62. The degree of dissociation of PCl_5 at this temperature will be

(a) 6.8% (b) 68% (c) 46% (d) 64%

66. For an elementary reaction, the specific rate constants for forward and reverse reactions are 0.50 and 5×10^4 respectively. The equilibrium constant for the reaction would be

(a) 2.5×10^3 (b) 2.5×10^4
(c) 1×10^{-5} (d) 1×10^5

67. The weakest base among the following is

(a) H^- (b) CH_3^- (c) CH_3O^- (d) Cl^-

68. The concentration of $[H^+]$ and concentration of $[OH^-]$ of a 0.1 M aqueous solution of 2% ionised weak acid is [ionic product of water = 1×10^{-14}]
(a) 0.02×10^{-3} M and 5×10^{-11} M
(b) 1×10^{-3} M and 3×10^{-11} M
(c) 2×10^{-3} M and 5×10^{-12} M
(d) 3×10^{-2} M and 4×10^{-13} M

69. The molal elevation constant of a liquid is the ratio of elevation in boiling point to
(a) molality (b) normality
(c) molarity
(d) mole fraction of solvent

70. Osmotic pressure of 30% solution of glucose is 1.20 bar and that of 3.42 % solution of cane sugar is 2.5 bar. The osmotic pressure of the mixture containing equal volumes of the two solutions will be
(a) 2.5 atm (b) 3.7 atm
(c) 1.85 atm. (d) 1.3 atm.

71. Determination of correct molecular mass by measuring colligative property applies to
(a) an electrolyte in solution
(b) an non-electrolyte in dilute solution
(c) a volatile solute
(d) an electrolyte in concentrated solution.

72. The molecular velocities of two gases at same temperature are u_1 and u_2. Their masses are m_1 and m_2 respectively, which of the following expression is correct ?
(a) $\frac{m_2}{u_1^2} = \frac{m_2}{u_2^2}$ (b) $m_1u_1 = m_2u_2$
(c) $m_1u_2 = m_2u_1$ (d) $m_1u_1^2 = m_2u_2^2$

73. 1.12×10^{-7} cc of O_2 at S.T.P. contains molecules equal to
(a) 3.10×10^{12} (b) 3.01×10^{20}
(c) 3.01×10^{24} (d) 3.01×10^{23}

74. The unit cell belongs to which of the following type
(a) Primitive cubic (b) End centred cubic
(c) Body centred cubic (d) Face centred cubic

75. The site occupied by the anion A^- in the crystal lattice is
(a) triangular hole (b) cubical hole
(c) tetrahedral hole (d) octahedral hole

76. The value of ΔH for the process $I_{(g)} + e^-_{(g)} \rightarrow I^-_{(g)}$ is
(a) >0 (b) <0 (c) >0 (d) <0

77. Enthalpy of neutralisation of acetic acid with KOH will be numerically
(a) = 57.1 kJ (b) > 57.1 kJ
(c) < 57.1 kJ (d) unpredictable.

78. In which of the following process entropy increases?
I. Rusting of iron
II. Vaporisation of camphor
III. Crystallisation of sugar from syrup
IV. Atomisation of dihydrogen.
(a) I, II (b) II, III
(c) I, IV (d) Only IV

79. The heat evolved during the combustion of 46 g ethanol in a bomb calorimeter was determined to be 670.48 kcal mol^{-1} at 25°C. The value of ΔE of the reaction at the same temperature is
(a) – 335.24 kcal (b) – 669.28 kcal
(c) – 670.48 kcal (d) – 280.26×10^4 kcal

80. The values of $E^0_{Zn/Zn^{2+}} = -0.76$ V and that of $E^0_{Fe^{2+}/Fe} = -0.41$ V. The E^0_{cell} of the cell with net cell reaction
$Zn + Fe^{2+} \rightarrow Zn^{2+} + Fe$ is
(a) – 0.35 V (b) – 1.17 V
(c) – 1.17 V (d) + 0.35 V

81. In the diagram given below the value of X is

$$Cu^{2+} \xrightarrow{+0.15\text{ V}} Cu^+ \xrightarrow{+0.50\text{ V}} Cu$$
$$E^0 = X \text{ volt}$$

(a) 0.325 V (b) 0.65 V
(c) – 0.35 V (d) – 0.65 V

82. The molar ionic conductance at infinite dilution of Ag^+ is 61.92×10^{-4} S mol^{-1} m^2 at 25°C. The ionic mobility of Ag^+ will be
(a) 6.4×10^{-8} (b) 6.192
(c) 6.192×10^{-4} (d) 3.2×10^{-4}

83. For the cell reaction to be spontaneous
(a) $E^0_{cell} > 0$ (b) $E^0_{cell} < 0$
(c) $\Delta G > 0$ (d) $\Delta G = 0$

84. Which statement about $Na_2S_4O_6$ is correct ?
(a) O.N. of all atoms is 2.5
(b) Two S atoms have O.N. +2 while other two have O.N. +3
(c) Three S atoms have O.N. +3 while the fourth S atoms has O.N. +4
(d) Two S atoms have O.N. +5 while, the other two S atoms have O.N.=0

85. In the following half reaction, $C_2O_4^{2-} \rightarrow 2CO_2 + xe^-$ the value of x is
(a) 1 (b) 2 (c) 3 (d) 4

86. In the reaction,
$$2H_2O_2 + 2ClO_2 + 2OH^- \rightarrow 2Cl^- + 5O_2 + 6H_2O,$$
the substance oxidised is
(a) H_2O_2 (b) ClO_2

(c) OH^- (d) unpredictable.

87. One mole of N_2H_4 loses 10 moles of electrons to form a new compound Y. Assuming that all nitrogen appears in the new compound, the oxidation state of nitrogen in the new compound will be
(a) + 3 (b) + 5 (c) – 1 (d) – 3.

88. $xI_2 + ySO_2 + zH_2O \rightarrow aSO_4^{2-} + bI^- + cH^+$. The values of z, b, c are respectively
(a) 1, 1, 2 (b) 2, 2, 4 (c) 1, 2, 4 (d) 2, 4, 2

89. Migration of colloidal particles under the effect of an electric field is known as
(a) electro-osmosis (b) electro-phoresis
(c) electro-dialysis (d) dialysis.

90. Which of the following statement is true for physical adsorption ?
(a) It is also known as Langmuir adsorption
(b) Heat of adsorption is about 100 kJ mol^{-1}
(c) Extent of adsorption increases with increase in temperature
(d) It is not specific.

91. The Rubin number which was proposed by Ostwald as an alternative to the Gold number in order to measure the protective efficiency of a lyophilic colloid may be defined as the
(a) mass in milligrams of a colloid per 100 c.c. of solution which just prevents the colour change of standard sol of dye Congo-Rubin from red to violet when 0.16 g eq. KCl is added to it.
(b) mass in grams of a colloid per 100 c.c. of solution which just prevents the colour change of standard sol of dye Congo-Rubin from red to violet when 0.1 M KCl is added to it.
(c) mass in grams of a colloid per 100 c.c. of solution which just prevents the colour change of standard sol of dye Congo-Rubin from red to violet when 0.2 M KCl is added to it.
(d) mass in grams of a colloid per 100 c.c. of solution which just prevents the colour change of standard sol of dye Congo-Rubin from red to violet when 1 M KCl is added to it.

92. Which one of the following will have the highest coagulating power for a ferric hydroxide sol ?
(a) NaCl (b) $BaCl_2$
(c) K_2CrO_4 (d) $K_3[Fe(CN)_6]$

93. Radium has atomic weight 226 and a half-life of 1600 years. The number of disintegrations produced per second from 1 g are 3.7×10^{10}
(a) 4.8×10^{10} (b) 9.2×10^{6}
(c) 4.8×10^{10} (d) zero

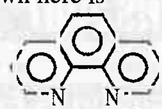
94. The activity of a radioactive nuclide (X^{100}) is 6.023 curie. If its disintegration constant is 3.7×10^4 sec^{-1}, the mass of X is
(a) 10^{-3} g (b) 10^{-15} g (c) 10^{-6} g (d) 10^{-14} g

95. The decay constant of a radioactive sample is λ. The half-life and mean life of the sample are respectively.
(a) $\frac{1}{\lambda}, \ln\frac{2}{\lambda}$ (b) $\frac{\ln 2}{\lambda}, \frac{1}{\lambda}$
(c) $\lambda \ln 2, \frac{1}{\lambda}$ (d) $\frac{\lambda}{\ln 2}, \frac{1}{\lambda}$

96. Which of the following pairs of ions when mixed in dilute solutions may give precipitate ?
(a) Na^+, SO_4^{2-} (b) NH_4^+, CO_3^{2-}
(c) Na^+, S^{2-} (d) Fe^{3+}, PO_4^{3-}

97. An aqueous solution of 6.3 g oxalic acid dehydrate is made up to 250 ml. The volume of 0.1N NaOH required to completely neutralize 10 ml of this solution is
(a) 40 ml (b) 20 ml (c) 10 ml (d) 4 ml

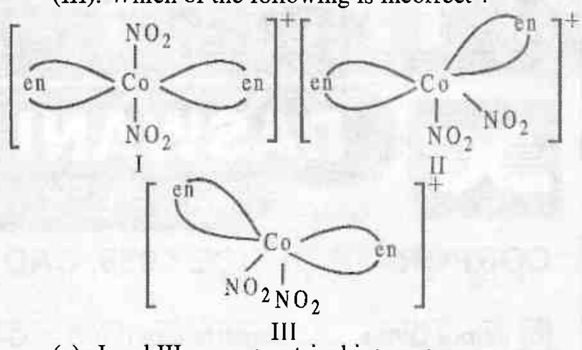
98. The ligand shown here is



(a) tridentate (b) 1,10-phenanthroline
(c) 1,10 phenanthrine (d) 2,2-dipyridyl.

99. Which of the following complex will give white precipitate with barium chloride solution ?
(a) $[Cr(NH_3)_5Cl]SO_4$ (b) $[Cr(NH_3)SO_4]Cl$
(c) $[CO(NH_3)_6]Br_3$ (d) None of these

100. Three arrangements have been shown for the complex cation bis-(ethylenediamine)dinitro cobalt (III). Which of the following is incorrect ?



(a) I and III are geometrical isomers
(b) II and III are geometrical isomers
(c) I and II are geometrical isomers
(d) II and III are optical isomers

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BIOLOGY

101. Which of the following is a true sequence?
(a) observation, hypothesis, experiment, theory
(b) observation, hypothesis, theory, experiment
(c) theory, hypothesis, observation, experiment
(d) experiment, hypothesis, theory, observation.

102. Who coined the term taxonomy ?
(a) Waksman (b) A.P. decandole
(c) Leuwenhoek (d) Louis Pasteur

103. Kalpvriksha is the name of
(a) banyan tree (b) peepal tree
(c) coconut tree (d) palm tree

104. In the book *Historia Naturalis* about 1000 medicinal plants were described which was written by
(a) Pliny (b) Linnaeus
(c) Caesalpino (d) Tippo

105. The term phylum in taxonomy was given by
(a) C. Linnaeus (b) G.L. Cuvier
(c) John Ray (d) E.H. Haeckel

106. Taxon is
(a) species
(b) unit of classification
(c) highest rank in classification
(d) group of closely related families

107. Viroids have
(a) single stranded RNA not enclosed by protein coat
(b) single stranded DNA not enclosed by protein coat
(c) double stranded DNA enclosed by protein coat
(d) double stranded RNA enclosed by protein coat

108. *Yersinia pestis* is causative agent of
(a) syphilis (b) leprosy
(c) whooping cough (d) plague

109. In plant, Citrus canker is caused by
(a) virus (b) algae
(c) fungus (d) bacterium

110. Agar-agar which is commonly used in microbiological studies and culture media is obtained from
(a) *Gelidium* (b) *Laminaria*
(c) *Polysiphonia* (d) *Batrachospermum*

111. Dinoflagellates are considered connecting link between Monera and Protista because
(a) they spin while they move
(b) they have flagella in grooves
(c) they show bioluminescence
(d) they have condensed chromosomes lacking histone proteins.

112. Red rust of tea is caused by
(a) *Puccinia* (b) *Cephaleuros*
(c) both (a) and (b) (d) none of these

113. Pteridophytes differ from bryophytes in having
(a) vascular tissues (b) archegonia
(c) motile antherozoids
(d) alternation of generation

114. If the number of chromosome in nucellus is 48 then what will be the number of chromosome in endosperm of *Ephedra* ?
(a) 48 (b) 72 (c) 24 (d) 96

115. In active non-osmotic absorption of water the OP of the cell sap of root hairs is ....than/to OP of the soil water
(a) higher (b) lower
(c) both (a) and (b) (d) equal

116. The role which can be assigned to plasma membrane is
(a) it gives passage to water
(b) it gives passage to solutes and water
(c) it gives passage to water and solutes only into the cell
(d) it helps in movement of cell contents out of the cell.

117. The osmotic potential is denoted by
(a) Ψ_v (b) $\Delta\Psi$ (c) Ψ_p (d) Ψ_s

118. Loss of water from the tips of leaves is called
(a) guttation (b) transpiration
(c) respiration (d) bleeding

119. Rate of transpiration can be measured by
(a) Ganong's potometer (b) porometer
(c) auxanometer (d) respirometer

120. The element which is not of much importance to plants is
(a) Ca (b) Zn (c) Cu (d) Na.

121. Nonsymbiotic anaerobic nitrogen fixation bacteria is
(a) *Azotobacter* (b) *Frankia*
(c) *Clostridium* (d) *Azolla*

122. In one of the following plant types both PEP carboxylase and RuBP carboxylase are present in the cell chloroplast
(a) CAM (b) C_4
(c) C_3 (d) CAM and C_4

123. Rubisco protein comprise ....% of total chloro plast
(a) 4 (b) 40 (c) 16 (d) 20

124. Who of the following proposed photoperiodism ?
(a) Garner and Allard (b) Darwin
(c) Lysenko (d) Arnon

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Contd. from page no. 26

125. Which of the following is incorrect statement?
(a) C_4 plants also show C_2 cycle
(b) C_3 plants respire in presence of light
(c) C_4 plants also exhibit Calvin cycle
(d) C_3 plants lack Hatch Slack pathway

126. At which step CO_2 joins photosynthesis?
(a) first step of light reaction
(b) last phase of light reaction
(c) first step of photophosphorylation
(d) dark phase or the first step of Calvin cycle.

127. Which of the following provides energy to ETS by absorption of sunlight ?
(a) chlorophyll (b) mitochondria
(c) ATP (d) water

128. In sugarcane plant CO_2 is fixed in malic acid, in which the enzyme that fixes CO_2 is
(a) ribulose biphosphate carboxylase
(b) phosphenol pyruvic acid carboxylase
(c) ribose phosphate kinase
(d) fructose phosphatase

129. Electron acceptor in PS II is
(a) FRS (b) PQ (c) cyt b (d) Fe

130. Succulent plants have respiratory quotient less than one because of
(a) complete oxidation (b) complete reduction
(c) incomplete oxidation (d) incomplete reduction

131. Vinegar is synthesized from alcohol by
(a) *Mycobacterium aceti* (b) *Acetobacter aceti*
(c) *Lactobacillus* (d) both (a) and (b)

132. Which of the following cells do not respire?
(a) cortical cells (b) epidermal cells
(c) RBC (d) xylem cells

133. The respiratory enzymes in the aerobic bacteria are located mainly in
(a) liposomes (b) mitochondria
(c) chondrioids (d) polysomes

134. How many ATP molecules are formed in ETS from the reduced nicotinamide adenine dinucleotide generated in one cycle of Krebs cycles ?
(a) 3 (b) 6 (c) 9 (d) 12

135. Pyruvic acid enters TCA in the form of
(a) OAA (b) malic acid
(c) Acetyl CoA (d) citric acid

136. Acetyl CoA is synthesized in
(a) cytosol
(b) inner membrane of mitochondria
(c) matrix of mitochondria
(d) F_1 particles of mitochondria

137. Female gametophyte of angiospermic plants is represented by
(a) oospore (b) embryosac
(c) carpel (d) pollen grain

138. Pollen grains are not green but yellow because
(a) plastids are absent
(b) plastid chloroplast changes to chromoplast
(c) they degenerates at the time when pollen grains shed
(d) for attraction of vectors.

139. Pollen grains are able to withstand extremes of temperature and dessication because their exine is composed of
(a) cutin (b) suberin
(c) sporopollenin (d) callose

140. In *Casuarina* fertilization occurs by
(a) chalazogamy (b) mesogamy
(c) porogamy (d) apogamy

141. The formation of embryo sac is called
(a) megasporogenesis (b) megagametogenesis
(c) microgametogenesis (d) none of these

142. A type of pollination in which flower remains closed is
(a) dicliny (b) chasmogamous
(c) dichogamous (d) none of these

143. Pollination in *Vallisneria* is by
(a) wind (b) animals
(c) insects (d) water

144. Growth is maximum in the zone of
(a) cell division (b) cell elongation
(c) cell maturation (d) all of these.

145. Skoog and Miller are associated with discovery of
(a) cytokinin (b) auxin
(c) gibberellin (d) both (a) and (c)

146. The growth hormones responsible for bolting, are
(a) auxins (b) kinetins
(c) coumarins (d) gibberellins

147. Most of the plant's auxin occurs in
(a) leaves (b) lateral buds
(c) shoot apex (d) root apical meristem

148. The level of which of the following increases during water stress?
(a) ethylene (b) abscisic acid
(c) indole-3-acetic acid (d) gibberellins

149. Genetical dwarfness can be overcome by treating it with

(a) auxins (b) gibberellins
(c) anti-gibberellins (d) ethylene.

150. Abscisic acid causes
(a) faster leaf fall (b) retardation of growth
(c) dormancy of tuber (d) all of these

151. Recently discovered vitamin having anticancer properties is
(a) Vitamin B[illegible] (b) Vitamin B_{15}
(c) Vitamin B_{17} (d) Vitamin Q

152. Tonics made out of the liver are very effective in curing haemopoietic disorder because
(a) they contain proteins
(b) they contain RBCs
(c) they contain bile juice
(d) they contain vitamin B_{12}

153. Find the odd one
(a) Vitamin K, prothrombin
(b) Zinc, Carbonic anhydrase
(c) Vitamin B_1, Paralysis
(d) Sulphur, Phosphatase

154. Black tongue disease is associated with the deficiency of
(a) Menadione (b) Niacin
(c) Retinol (d) Calciferol

155. Clara cells in the respiratory system are present with
(a) Trachea, release mucus
(b) Trachea, release lecithin
(c) Respiratory bronchioles, release mucus
(d) Respiratory bronchioles, release lecithin

156. If thorax is injured and pleura damaged, the air enters the pleural cavity and the lungs are collapse. This condition is known as
(a) Hyponea (b) Orthopnoea
(c) Dyspnoea (d) Pneumothorax

157. Which of the following gases makes the most stable combination with the haemoglobin of red blood cells?
(a) CO_2 (b) CO (c) O_2 (d) N_2

158. Which of the following statements is incorrect ?
(a) Atelectasis occurs due to the lack of surfactant and Pneumothorax.
(b) There are 3 lobes in right lung and 2 lobes in the left lung of man.
(c) Asphyxia occurs due to acute hypercapnia.
(d) In methaemoglobin, ferric ions are converted into ferrous.

159. Which one of the following is a matching pair ?
(a) Dubb-opening of the semilunar valves at the beginning of ventricular diastole.
(b) Lubb-closure of atrioventricular valves immediately after the start of ventricular systole.
(c) Purkinje fibres-initiation of heart beat.
(d) Pulsation of radial artery-valves in blood vessels.

160. A portal system is one in which
(a) a vein starts from an organ and ends up in heart
(b) a vein starts from an organ and ends up in another organ
(c) a vein starts from heart and ends up in lungs
(d) none of these

161. Lymph differs from blood in possessing
(a) more proteins and less waste products
(b) less proteins and more waste products
(c) more proteins and more waste products
(d) less proteins and less waste products

162. Which of the following wave of ECG shows ventricular depolarization ?
(a) P wave (b) QRS wave
(c) T wave (d) U wave

163. Which of the following statements is wrong ?
(a) The counter current mechanism changes the isotonic glomerular filtrate into a hypertonic urine by increasing salt concentration around the nephron and collecting tubule.
(b) The wall of collecting tubule is permeable to water whereas ascending limb is impermeable to water.
(c) The urine leaving the DCT is nearly as concentrated as the interstitial fluid deep in the medulla.
(d) As the filtrate passes through the ascending limb, sodium is transported passively and chloride ions pass out actively into the interstitial fluid.

164. Angiotensin - II increases the blood volume by
(a) signalling PCT to reabsorb more NaCl and water
(b) stimulating adrenal gland to release aldosterone
(c) by stimulating the release of ADH
(d) all of these

165. When the volume of body fluid falls below normal, ADH
(a) decreases permeability of distal convoluted tubule and collecting tubule
(b) increases permeability of distal convoluted tubule and collecting tubule
(c) has nothing to do with permeability of convoluted tubule
(d) none of these

166. Vitamin excreted by urine in higher vertebrates is
(a) A (b) D (c) K (d) C

167. Which of the following are involved in the formation of the acetabulum ?

(i) Ilium (ii) Ischium (iii) Pubis
(a) i & ii only (b) ii & iii only
(c) i & iii only (d) i, ii & iii

168. The cells responsible for the resorption of bone matrix during the growth and remodelling of the skeleton are called
(a) osteoblasts (b) osteoclasts
(c) chondroblasts (d) chondroclasts

169. Bone formed by the ossification of tendon is called as
(a) sesamoid
(b) cartilage or replacing bone
(c) isnvesting or dermal bone
(d) none of these

170. Uncinate process is the typical feature of
(a) Verterbral column - Birds
(b) Vertebral column - Reptiles
(c) Ribs - Birds
(d) Ribs - Reptiles

171. Which of the following transmits impulses from one side of the cerebellum to the other?
(a) Pons varolii (b) Crura cerebri
(c) Corpora quadrigemina
(d) Cerebellum

172. Branched tree like structure present in cerebellum and made up of white matter is
(a) arborial (b) areolae
(c) arbor vitae (d) archenteron

173. The CSF moves from ventricle of the brain to subarachnoid space through
(a) foramina Magendie (b) foramina Luschka
(c) foramen of Monro (d) both (a) and (b)

174. Trigeminal nerve arises from brain in the region of
(a) pons Varolii and divides into palatine, chorda tympani and hyomandibular
(b) medulla and divides into palatine, hyomandibular and chorda tympani
(c) cerebellum and divides into ophthalmic, maxillary and mandibular
(d) pons Varolii and divides into ophthalmic, maxillary and mandibular

175. Inhibition of uterine contraction ceases and the bleeding and cramps of menstruation begin, when the level of progesterone in the blood is
(a) low (b) normal
(c) high (d) very high

176. Which of the following product PIP_2 diffused into the cytoplasm triggering the release of Ca^{2+} for intracellular calcium mediated processes?
(a) IP_3 (b) DG
(c) cAMP (d) Protein kinase -A

177. During mechanism of action of insulin, protein kinase C is activated by
(a) P_1P_2 (b) IP_3 (c) DG (d) Ca^{2+}

178. Which of the following hormones binds with intracellular receptors?
(a) Thyroid hormone (b) Catecholamine
(c) Peptide hormone (d) All of these

179. Fertilizin proteins are associated with
(a) corona radiata of the ovum
(b) zona pellucida of the ovum
(c) acrosome of the sperm
(d) tail part of the sperm

180. Cells of Rauber are
(a) trophoblast cells in contact with embryonal
(b) cells of inner cell mass
(c) cells present in the blastocoel
(d) uterine epithelial cells making contact with blastocyst

181. The mesoderm gives rise to all structures except
(a) nervous system (b) muscular system
(c) circulatory system (d) gonads

182. If both the ovaries of a pregnant female are removed in the second trimester it will lead to
(a) abortion
(b) slow development of fetus
(c) normal development
(d) premature birth

183. Inner surface of fallopian tubes, bronchi and bronchioles are lined by
(a) squamous epithelium (b) ciliated epithelium
(c) columnar epithelium (d) cubical epithelium

184. The mast cells secrete the following substance
(a) heparin (b) histamine
(c) serotonin (d) all of these

185. Urethra, vagina and oesophagus have a common inner lining of
(a) squamous epithelium (b) ciliated epithelium
(c) columnar epithelium
(d) stratified squamous epithelium

186. Stratum germinativum is an epithelium of the type
(a) squamous (b) ciliated
(c) columnar (d) cuboidal

187. The horns of rhinoceros are composed of
(a) bone (b) cartilage
(c) chitin (d) keratin

188. In mammals, the melanocytes give protection from
(a) UV rays (b) infrared rays
(c) X-rays (d) visible light

189. Duodenum has characteristic Brunner's glands which secrete two hormones called
(a) prolactin, parathormone
(b) estradiol, progesterone
(c) kinase, estrogen
(d) secretin, cholecystokinin

190. Gall bladder is stimulated by
(a) secretin (b) cholecystokinin
(c) enterogastrone (d) enterokinase

191. A lubricant, mucin in saliva is made up of
(a) glycoprotein (b) polysaccharides
(c) phospholipids (d) myosin

192. Severe acute respiratory syndrome (SARS)
(a) is caused by a variant of *Pneumococcus pneumonae*
(b) is caused by a variant of the common cold virus (corona virus)
(c) is an acute form of asthma
(d) affects non-vegetarians much faster than the vegetarians.

193. Which one of the following commonly forms renal stones in ureter and cause severe pain during urination ?
(a) Oxalate salt (b) Citrate salt
(c) Uric acid (d) Carbonate salt

194. The respiratory centre in the brain is stimulated by
(a) CO_2 conc. in venous blood
(b) O_2 conc. in arterial blood
(c) CO_2 conc. in arterial blood
(d) O_2 conc. in venous blood

195. Systemic heart refers to
(a) the heart that contracts under stimulation from nervous system
(b) left auricle and left ventricle in higher vertebrates
(c) entire heart in lower vertebrates
(d) the two ventricles together in humans.

196. Haemophilia is caused by
(a) factor V (b) factor VIII
(c) factor III (d) none of these

197. Movement of WBCs out of capillaries is called
(a) translocation (b) phagocytosis
(c) diapedesis (d) pinocytosis.

198. RASS operated during which condition
(a) low BP & low Blood volume
(b) high BP & high Blood volume
(c) both (a) and (b) (d) none of these

199. Which one of the following statements is correct with respect to salt water balance inside the body of livng organisms?
(a) When water is not available camels do not produce urine but store urea in tissues.
(b) Salmon fish excretes lot of stored salt through gill membrane when in fresh water.
(c) Paramecium discharges concentrated salt solution by contractile vacuoles.
(d) The body fluids of fresh water animals are generally hypotonic to surrounding water.

200. If a person dependent on maize food grain in future he suffers from deficiency of which vitamin?
(a) Retinol (b) Niacin
(c) Thiamine (b) Calciferol ❖

ANSWERS

1.	(b)	2.	(a)	3.	(b)	4.	(c)	5.	(a)
6.	(b)	7.	(a)	8.	(b)	9.	(b)	10.	(b)
11.	(c)	12.	(c)	13.	(b)	14.	(b)	15.	(d)
16.	(d)	17.	(a)	18.	(c)	19.	(b)	20.	(c)
21.	(a)	22.	(d)	23.	(d)	24.	(c)	25.	(a)
26.	(b)	27.	(d)	28.	(a)	29.	(b)	30.	(c)
31.	(d)	32.	(c)	33.	(c)	34.	(a)	35.	(c)
36.	(d)	37.	(a)	38.	(c)	39.	(b)	40.	(c)
41.	(b)	42.	(a)	43.	(c)	44.	(d)	45.	(a)
46.	(d)	47.	(d)	48.	(d)	49.	(a)	50.	(c)
51.	(b)	52.	(b)	53.	(c)	54.	(b)	55.	(d)
56.	(a)	57.	(a)	58.	(b)	59.	(b)	60.	(a)
61.	(a)	62.	(b)	63.	(d)	64.	(d)	65.	(b)
66.	(c)	67.	(d)	68.	(c)	69.	(a)	70.	(c)
71.	(b)	72.	(d)	73.	(a)	74.	(a)	75.	(b)
76.	(b)	77.	(c)	78.	(c)	79.	(c)	80.	(d)
81.	(a)	82.	(a)	83.	(a)	84.	(d)	85.	(b)
86.	(a)	87.	(b)	88.	(b)	89.	(b)	90.	(d)
91.	(a)	92.	(d)	93.	(c)	94.	(b)	95.	(b)
96.	(d)	97.	(a)	98.	(b)	99.	(a)	100.	(b)
101.	(a)	102.	(b)	103.	(c)	104.	(a)	105.	(b)
106.	(b)	107.	(a)	108.	(d)	109.	(d)	110.	(a)
111.	(b)	112.	(d)	113.	(a)	114.	(c)	115.	(b)
116.	(b)	117.	(d)	118.	(a)	119.	(a)	120.	(d)
121.	(c)	122.	(a)	123.	(c)	124.	(a)	125.	(a)
126.	(d)	127.	(a)	128.	(b)	129.	(b)	130.	(c)
131.	(b)	132.	(c)	133.	(c)	134.	(c)	135.	(c)
136.	(c)	137.	(b)	138.	(a)	139.	(c)	140.	(a)
141.	(b)	142.	(d)	143.	(d)	144.	(b)	145.	(a)
146.	(d)	147.	(c)	148.	(b)	149.	(b)	150.	(d)
151.	(c)	152.	(d)	153.	(d)	154.	(b)	155.	(d)
156.	(d)	157.	(b)	158.	(d)	159.	(b)	160.	(b)
161.	(b)	162.	(b)	163.	(d)	164.	(d)	165.	(b)
166.	(d)	167.	(d)	168.	(b)	169.	(a)	170.	(c)
171.	(a)	172.	(c)	173.	(d)	174.	(d)	175.	(a)
176.	(a)	177.	(c)	178.	(a)	179.	(b)	180.	(a)
181.	(a)	182.	(c)	183.	(b)	184.	(d)	185.	(d)
186.	(c)	187.	(d)	188.	(a)	189.	(d)	190.	(b)
191.	(a)	192.	(b)	193.	(a)	194.	(c)	195.	(b)
196.	(b)	197.	(c)	198.	(a)	199.	(a)	200.	(b)

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Thought Provoking Problems in Projectile Motion

By : Prof. Rajinder Singh Randhawa*

1. If V be the velocity of projection and V_1 the velocity of striking the plane when projected so that range up the plane is maximum, and V_2 the velocity of striking the plane when projected so that the range down the plane is maximum, Prove that $V = \sqrt{V_1 V_2}$

2. A ball is thrown from a point in level with and at a horizontal distance R from the top of a tower of height H. How must the speed and angle of projection of the ball be related to R in order that the ball may just go grazing past the top edge of the tower? At what horizontal distance r from the foot of the tower does the ball hit the ground? For a given speed of projection, obtain an equation for finding the angle of projection so that r is at a minimum.

3. Two persons simultaneously aim their guns at a ball kept on a tower. The first person releases his 'shot' with a speed of 100 ms^{-1} at an angle 30°. The second person is ahead of the first by a distance of 50 m and releases his 'shot' with a speed of 80 ms^{-1}.
   (a) How must he aim his gun so that both "shots" hit the ball simultaneously?
   (b) What is the distance of the foot of the tower from the two persons and the height of the tower?

4. A projectile is fired from the base of cone-shaped hill. The projectile grazes the vertex and strikes the hill again at the base. If δ be the half-angle of the cone, H its height, V the initial velocity of projection and ϕ the angle of projection, show that

$\phi = \tan^{-1}(2\cot\delta)$ and $V = \sqrt{2gH\left(1+\frac{1}{4}\tan^2\delta\right)}$.

5. An aeroplane flies horizontally at a height 'h' at a speed v. An anti-aircraft gun fires a shell at the plane when it is vertically above the gun. Find the minimum muzzle velocity required to hit the plane and also angle with which it is projected?

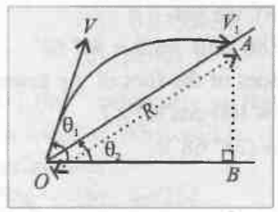
6. From a point on the ground at a distance 'a' from the foot of a pole, a ball is thrown, at an angle of 45°, which just touches the top of pole and strikes the ground at a distance of 'b', on the other side of it. Find the height of the pole.

7. If v be the velocity and α its inclination to the horizontal at any point on its path for a projectile, show that, it is at right angles to the former direction after a time $v/g\sin\alpha$.

SOLUTIONS

1. The max. range along inclined plane is

$$R = \frac{V^2}{g(1+\sin\theta_2)} = OA$$



$\therefore$ The height $AB = R\sin\theta_2 - \frac{V^2\sin\theta_2}{g(1+\sin\theta_2)}$

Velocity at A, is V_1, then $V^2 = V_1^2 + 2g\,(AB)$

$$V^2 = V_1^2 + 2g\frac{(V^2\sin\theta_2)}{g(1+\sin\theta_2)} \Rightarrow V_1^2 = \frac{V^2(1-\sin\theta_2)}{(1+\sin\theta_2)} \quad ...(1)$$

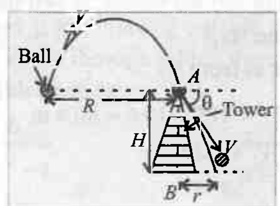
Similarly, maximum range down the plane is given by

$$R' = \frac{V^2\sin\theta_2}{g(1-\sin\theta_2)},\ \therefore V^2 = V_2^2 - 2g\left(\frac{V^2\sin\theta_2}{g(1-\sin\theta_2)}\right)$$

$$\Rightarrow V_2^2 - \frac{V^2(1+\sin\theta_2)}{(1-\sin\theta_2)} \quad ...(ii)$$

Multiply (i) and (ii), we get $V_1^2 V_2^2 = V^4 \Rightarrow V = \sqrt{V_1 V_2}$

2.



$R = V_x t$, $R = V\cos\theta\,\frac{2V\sin\theta}{g} = \frac{V^2\sin 2\theta}{g}$

$Rg = V^2\sin 2\theta \quad ...(i)$

Also, $H = (V\sin\theta)t + \frac{1}{2}gt^2$

Solve quadratic equation

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$\therefore\ t=\dfrac{-V\sin\theta\pm\sqrt{V^2\sin^2\theta+2gH}}{g}$ (Taking +ve sign)

$\therefore\ r=V\cos\theta t=\dfrac{V\cos\theta}{g}\left[\sqrt{V^2\sin^2\theta+2gH}-V\sin\theta\right]$ ...(ii)

The angle of projection θ for which r is minimum for a given value of V is given by $\dfrac{dr}{d\theta}=0$. Using (ii), we get

$V^2\sin 2\theta\cos 0-\sin 0\,(V^2\sin 2\theta+2gH)$

$-V\cos 2\theta\sqrt{V^2\sin^2\theta+2gH}=0$ ...(iii)

The angle of projection for which r is minimum is a solution of equation (iii).

3. For first person's shot,

(a) $H=(100\sin 30^\circ)t-(1/2)\times 9.8\,t^2$ ...(i)

For second person's shot,

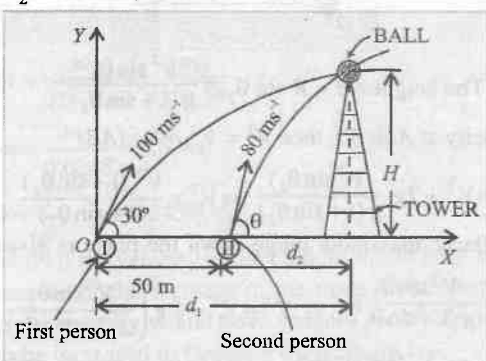
$H=(80\sin\theta)t-(1/2)\times 9.8\,t^2$ ...(ii)

From (i) and (ii), we get

$(100\sin 30^\circ)=80\sin\theta\Rightarrow\theta=38^\circ\,68'$

(b) The distances of the foot of the tower from the two persons are $d_1=100\cos 30^\circ\times t$ ...(iii)

and $d_2=80\cos(38^\circ\,68')t$ ...(iv)



$\therefore$ $100\cos 30^\circ\,t=50+80\cos(38^\circ\,68')t$ [From figure] which gives $t\sim 2$ sec is the time of the two "shots" hit the ball after firing. Using 't', we find $d_1\sim 180$ m and $d_2\sim 130$ m [From (iii) and (iv)]

Now, height of the tower is from (i)

$$H=100\times\frac{1}{2}\times 2-4.9\,(2)^2=100-19.6=80.4\text{ m}$$

4. Range $=2H\tan\delta=\dfrac{V^2\sin 2\phi}{g}$

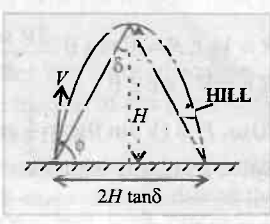
and $H=\dfrac{V^2\sin^2\phi}{2g}$

Dividing, $2\tan\delta=\dfrac{2\sin 2\phi}{\sin^2\phi}$

$\Rightarrow\tan\delta=2\cot\phi$

$\therefore\ \tan\phi=2\cot\delta$

$\Rightarrow\phi=\tan^{-1}(2\cot\delta)$



Now,

$$V^2=\frac{2gH}{\sin^2\phi}-\frac{2gH}{2\cot\delta/\sqrt{1+4\cot^2\delta}}=2gH\left(1+\frac{1}{4}\tan^2\delta\right)$$

$$\therefore\ V=\sqrt{2gH\left(1+\frac{1}{4}\tan^2\delta\right)}$$

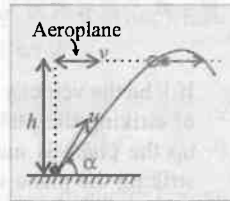
5. We have ; $vt=(u\cos\alpha)t$

$\Rightarrow\ v=u\cos\alpha$

$h=(u\sin\alpha)t-\frac{1}{2}gt^2$

$\Rightarrow\ \frac{1}{2}gt^2-(u\sin\alpha)t+h=0$

Since 't' is real



$u^2\sin^2\alpha>4\times\frac{1}{2}gh$

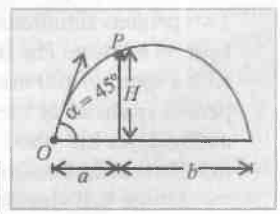
$\Rightarrow u^2\left(1-\dfrac{v^2}{u^2}\right)\ge 2gh\Rightarrow u\ge\sqrt{v^2+2gh}$

$\therefore u_{min}=\sqrt{v^2+2gh}$

Now, $\cos\alpha=\dfrac{v}{u_{min}}=\dfrac{v}{\sqrt{v^2+2gh}}\Rightarrow\tan\alpha=\dfrac{\sqrt{2gh}}{v}$

$\alpha=\tan^{-1}\left(\sqrt{2gh}/v\right)$

6. Let H be the height of the pole, using equation of trajectory,



$y=x\tan\alpha\left(1-\dfrac{x}{R}\right)$

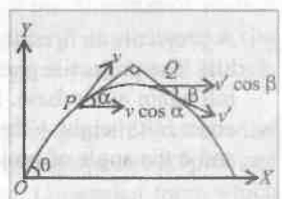
$\therefore\ H=a\tan 45^\circ\left[1-\dfrac{a}{a+b}\right]$

$H=\dfrac{ab}{a+b}$

7. Since the horizontal component of velocity remains constant throughout the motion,

$\therefore v\cos\alpha=v'\cos\beta$

But $\alpha+\beta=90^\circ$



$\therefore\ v'=\dfrac{v\cos\alpha}{\cos(90^\circ-\alpha)}\Rightarrow v'=v\cot\alpha$ ...(i)

As along vertical direction. initial velocity = $v\sin\alpha$;

Final velocity = $-v'\sin\beta$

$=-v\cot\alpha\sin(90^\circ-\alpha)=-v\cos^2\theta/\sin\theta$

Now, using $v=u+at$, $\begin{cases}a=-g\\ t=?\end{cases}$

$\therefore\ -\dfrac{v\cos^2\theta}{\sin\theta}=v\sin 0-gt$

$\Rightarrow gt=v\left[\sin\theta+\dfrac{\cos^2\theta}{\sin\theta}\right]=\dfrac{v}{\sin\theta}$

$\Rightarrow t=\dfrac{v}{g\sin\theta}$

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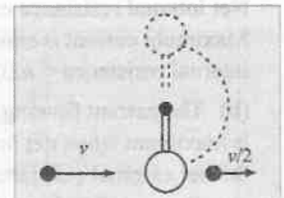
MULTIPLE CHOICE QUESTIONS WITH ONE CORRECT OPTION

1. A uniform meter stick is supported on a fulcrum at the 25 cm mark. A 0.50 kg object is hung from the 0 cm end of the meter stick, and the stick is balanced horizontally. The mass of the meter stick is
(a) 0.25 kg (b) 0.50 kg
(c) 0.75 kg (d) 1.0 kg.

2. The radius of the Earth is 6.37×10^6 m. Approximately, how fast is a person on the Equator moving due to the Earth rotation?
(a) 5 m/s (b) 50 m/s
(c) 500 m/s (d) 5000 m/s

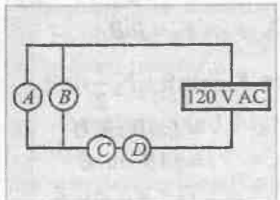
3. In a certain region of space, the electric field is zero. From this we can conclude that the electric potential in this region is
(a) constant (b) zero
(c) positive (d) negative.

4. A bullet of mass m and speed v hits a pendulum bob of mass M at time t_1, and passes completely through the bob. The bullet emerges at time t_2 with a speed of $v/2$. The pendulum bob is suspended by a stiff rod of length l and negligible mass. After the collision, the bob can barely swing through a complete vertical circle. At time t_3, the bob reaches the highest position. What quantities are conserved in this process?



(a) Total kinetic energy of the bob and the bullet during the time interval $\Delta t = t_2 - t_1$.
(b) Total momentum of the bob and the bullet during the time interval $\Delta t = t_2 - t_1$.
(c) Total mechanical energy of the bob and the bullet during the time interval $t_3 - t_1$.
(d) Momentum of the bob after t_2.

5. The diagram shows a circuit with four identical light bulbs. When we remove bulb A from the circuit, the light intensity of bulb C



(a) remains the same
(b) increases (c) decreases
(d) becomes zero.

6. The amplitude of an electromagnetic wave in vacuum is doubled with no other changes made to the wave. As a result of this doubling of the amplitude, which of the following statements is correct?
(a) The speed of propagation of the wave changes.
(b) The frequency of the wave changes.
(c) All of the above are true.
(d) None of the above is true.

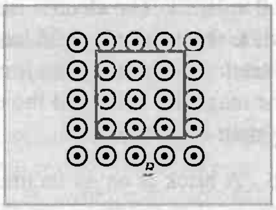
7. Two objects are initially at rest on a frictionless surface. Object 1 has a greater mass than object 2. The same constant force starts to act on each object. The force is removed from each object after it accelerates over a distance d. After the force is removed from both objects, which statement is correct (p is a momentum, K is a kinetic energy)?
(a) $p_1 < p_2$ (b) $p_1 > p_2$
(c) $K_1 > K_2$ (d) $K_1 < K_2$.

8. A dart is loaded into a spring-loaded toy dart gun by pushing the spring in by a distance d. For the next loading, the spring is compressed a distance $2d$. How much faster does the second dart leave the gun compared to the first?
(a) Four times as fast (b) Two times as fast
(c) The same (d) Half as fast

9. One of two parallel metallic plates is uniformly charged with charge $+q$, and the other one is charged with charge $-q$. In this case, the electric field between them is E. When the negatively charged plate is discharged and then recharged with a positive charge $4q$, the electric field between the plates becomes

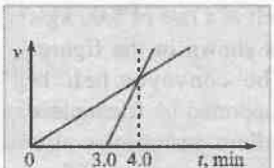
(a) 0 (b) $1.5\,E$
(c) $2.5\,E$ (d) $3E$

10. A uniform magnetic field B is directed out of the page. A metallic wire has the shape of a square frame and is placed in the field as shown. The shape of the wire is steadily transformed into a circle in the same plane, the current in the frame



(a) is directed clockwise
(b) does not appear
(c) is directed counterclockwise
(d) none of these.

11. The drawing shows velocity (v) versus time (t) graphs for two cyclists moving along the same straight segment of a highway from the same point. The second cyclist starts moving at $t = 3.0$ min. At what time do the two cyclists meet?

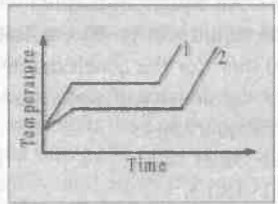


(a) 4.0 min (b) 6.0 min
(c) 12 min (d) 8.0 min.

12. Two solid spheres manufactured of the same material freely fall down in the air. One sphere has a diameter twice as large as the other. The force due to air resistance is proportional to the cross-sectional area of a moving object and is a quadratic function of the speed of an object. In some time after the beginning of motion in the presence of air resistance, the velocity of each sphere becomes constant. It is called the terminal velocity. The ratio of terminal velocities of the spheres v_{big}/v_{small} is
(a) 2 (b) $\sqrt{2}$
(c) $\frac{1}{2}$ (d) $\frac{1}{\sqrt{2}}$

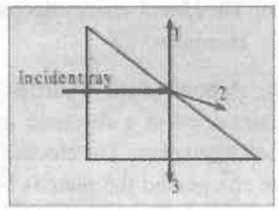
13. Astronauts are weightless in orbit because
(a) they are beyond the pull of gravity
(b) they travel in the accelerated frame of reference where centrifugal force is equal to centripetal force, and the net force on an astronaut is zero
(c) they are in free fall together with their spacecraft
(d) of another cause.

14. Two solid objects of the same mass are supplied with heat at the same rate $\Delta Q / \Delta t$. The temperature of the first object with latent heat L_1 and specific heat capacity c_1 changes according to graph 1 on the diagram. The temperature of the second object with latent heat L_2 and specific heat capacity c_2 changes according to graph 2 on the diagram. Based on what is shown on the graph, the latent heats L_1 and L_2, and the specific heat capacities c_1 and c_2 in solid state obey which of the following relationships?



(a) $L_1 > L_2;\ c_1 < c_2$ (b) $L_1 < L_2;\ c_1 < c_2$
(c) $L_1 > L_2,\ c_1 > c_2$ (d) $L_1 < L_2;\ c_1 > c_2$.

15. A light ray strikes a prism as shown in the drawing. The angles of the prism are 90°, 45°, and 45°. The critical angle of the prism material is 49°. What rays are the possible continuations of the incident ray?



(a) The ray 1 only (b) The ray 2 only
(c) The ray 3 only (d) Both rays 2 and 3.

16. You stand on a platform at a train station and listen to a train horn as the train approaches the station at a constant velocity. While the train approaches, but before it arrives, you hear
(a) the intensity and the frequency of the sound both increasing
(b) the intensity and the frequency of the sound both decreasing
(c) the intensity increasing and the frequency decreasing
(d) the intensity decreasing and the frequency increasing.

17. A linear conductor with current I_1 is placed along the axis of a circular conductor, which carries current I_2. The magnetic force acting on each of the conductors is
(a) zero
(b) directly proportional to the product of currents I_1 and I_2, and inversely proportional to the radius of the circular conductor
(c) directly proportional to the product of currents I_1 and I_2, inversely proportional to the square of the radius of the circular conductor
(d) directly proportional to the product of current I_1, current I_2, and the area of a circular conductor.

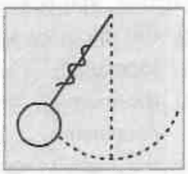
18. An aquarium is filled with water. The lateral wall of the aquarium is 40 cm long and 30 cm high. Using 10 m/s^2 for the acceleration due to gravity, and 1 g/cm^3 for the density of water, the force on the lateral wall of the aquarium is
(a) 36 N (b) 90 N
(c) 180 N (d) 1500 N.

19. A satellite is moved from one circular orbit around the earth, to another of lesser radius. Which of the following is true?
(a) The kinetic energy increases and the potential energy increases.
(b) The kinetic energy increases, and the potential energy decreases.
(c) The kinetic energy decreases and the potential energy decreases.
(d) The kinetic energy decreases and the potential energy increases.

20. A point particle carries a positive charge $+q$ and is maintained at a distance h above a large conductive uncharged plate. The electric force of interaction between the charge and the plate is best described as
(a) zero force
(b) an attractive force proportional to q/h^2
(c) an attractive force proportional to q^2/h^2
(d) an attractive force proportional to $q^2/4h^2$

QUESTIONS THAT REQUIRE GRAPHIC SOLUTIONS

21. A heavy pendulum bob is swinging back and forth when the string, supporting it, suddenly breaks. Ignoring the mass of the string and air resistance, draw the path of the subsequent motion of the bob if the string breaks when the bob is at its highest point.



22. A long vertical tube with a weightless movable piston inside has its lower end under the water. The tube is motionless throughout the experiment. The cross-sectional area of the piston is A. The initial position of the piston is just over the surface of the water. Then it is slowly moved upwards. Sketch a graph of the force necessary to lift the piston during its motion as a function of the height of the piston.

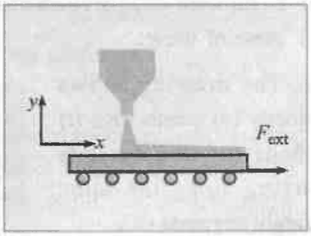
23. On the same graph, draw the following two functions: (i) kinetic energy versus speed of a particle according to classical mechanics and (ii) the same function for Einstein's relativistic theory.

24. An electron is moving at a constant velocity in a region of space with a uniform electric field of 1.0×10^3 N/C and a uniform magnetic field of 1.0×10^{-3} T. The electric field has only an x-component while the magnetic field has only a y-component. Sketch a vector diagram for the velocity of the electron, the magnetic field, and the electric field in the cartesian system of coordinates.

25. A brick is on an incline whose angle of inclination can be changed from 0 to 90 degrees.
Sketch a graph of the force of friction acting on the brick versus the angle of inclination in the given range.

SHORT ANSWER QUESTIONS

26. Sand from a stationary hopper falls onto a moving conveyor belt at a rate of 5.00 kg/s as shown in the figure. The conveyor belt is supported by frictionless rollers and moves at a constant speed of 0.75 m/s under the action of a constant horizontal external force F_{ext} supplied by the motor that drives the belt. Find



(i) the force of friction exerted by the belt on the sand
(ii) the external force F_{ext}
(iii) the work done by F_{ext} in 1 s
(iv) the kinetic energy acquired by the falling sand each second due to the change in its horizontal motion
(v) compare and analyse the answers to (iii) and (iv).

27. A source of electric power with electromotive force E and internal resistance r, is connected to a resistor.
(i) Find the power delivered to the resistor as a function of the resistance of the resistor.
(ii) Find the power produced by the source as a function of the resistance of the resistor.
(iii) Sketch graphs of these two functions.
(iv) Treating the efficiency of the source as a ratio of the power consumed to the power produced by the source, find the efficiency of the source of electric power as a function of the resistance of the resistor and sketch the graph of this function.
(v) Find the resistance of the resistor that corresponds to the maximum power delivered to the resistor, and calculate the efficiency for this resistance.

28. A point source of light is moving uniformly along a straight line, which intersects the optical axis of a converging lens under a small angle α at a distance $2F$

from the lens with a focal distance F. The speed of the source of light is v_0.

(i) Draw the lens, the trajectory of the source of light, and the trajectory of its image produced by the lens.

(ii) Draw the vector diagram for the velocity of the source of light, the velocity of the image, and the relative velocity of the image with respect to the source.

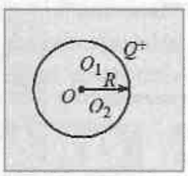
(iii) Determine the minimum relative speed of the image of the source of light with respect to the source.

SOLUTIONS

1. **(b)** : Condition of equilibrium for torques with respect to the fulcrum is:
$0.50 \times 0.25 = M \times 0.25 \Rightarrow M = 0.50$ kg

2. **(c)** : The relationship between the angular speed (ω) and the linear speed (v) gives:
$v = \omega R$, where R is the radius of the Earth.
If T is a period of rotation, $\omega = 2\pi/T$, and
$T = 24 \times 3600$ s.
$v = 2\pi R/T = 4.63 \times 10^2 \approx 500$ m/s

3. Consider uniformly charged spherical shell. The field any where is zero. As $\vec{E} = \frac{dV}{dx} = 0$, $V =$ constant. The potential is $\frac{1}{4\pi\varepsilon_0}\frac{Q^+}{R}$, a constant



(a). The potential is also positive (c). If Q is negative, the potential is also a negative (d).
If the shell is not charged, $E = 0$, $V = 0$ (b). If the question had been a uniformly charged sphere, the potential will be a constant and will be positive or negative depending on whether the charge is +ve or negative. If "it is a certain" region of space, whether it is enclosed or not is also not known, then not only the field is zero but the potential is also zero unless it is mentioned that it is a charged enclosure.

4. **(b)** : (a) and (c) are wrong, because of the energy loss during the motion of the bullet inside the bob, (d) is wrong, because an object experiences the external force of gravity that changes momentum, (b) is the correct answer.

5. **(c)** : The equivalent resistance of the part of circuit with the bulb B increases after the removal of the bulb A. This entails the reduction in current through the bulb C.

6. **(d)** : (d) is correct because an amplitude, a speed of propagation, and a frequency of the wave are independent variables.

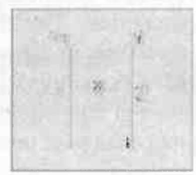
7. **(b)** : Object 2 has a greater acceleration because of its smaller mass. Therefore, it takes less time to travel the distance d. Even though the force applied to objects 1 and 2 is the same, the change in momentum is less for object 2 because Δt is smaller.

8. **(b)** : According to the law of conservation of energy, the potential energy of a spring transforms into the kinetic energy of a dart. The potential energy is proportional to the square of the compression, and kinetic energy is proportional to the square of the initial speed of the dart. Therefore, the speed increases the same number of times as the compression does.

9. **(d)** : At a particular point S, in between the plates, the field due to q^+ is added to q . However by the superposition of two Gaussian surfaces,

$$\underset{\text{due to } q^+}{E.A} + \underset{\text{due to } q^-}{E.A} = \underset{\substack{\text{to the right}\\ \text{from } P \text{ to } S}}{\frac{\sigma A}{\varepsilon_0}} + \underset{\substack{\text{to the right}\\ \text{from } S \text{ to } Q}}{\frac{\sigma A}{\varepsilon_0}}$$

Thus the field is $E = \frac{\sigma}{\varepsilon_0}$ where $\sigma = \frac{q}{A}$. If instead of q^- one has $4q^+$, the field due to $4q = \frac{4\sigma}{\varepsilon_0}$ to the left and that due to $+q = \frac{\sigma}{\varepsilon_0}$ to the right. Therefore the



resultant field is $\underset{\substack{\text{to the}\\ \text{left}}}{\frac{4\sigma}{\varepsilon_0}} - \underset{\substack{\text{to the}\\ \text{right}}}{\frac{\sigma}{\varepsilon_0}} = \frac{3\sigma}{\varepsilon_0}$ or $3E$ where $E = \frac{\sigma}{\varepsilon_0}$. The answer should be (d) and not (b).

The reason why there is need to take one gaussian surface for one plate and full discussions are given in the author's book, Beyond the Barriers (Extension lectures in physics) by Krishnan, T.V.

10. **(a)** : The area of a circle is greater than the area of a square with the same perimeter. During the transformation of the shape of the frame, the magnetic flux through the frame is increasing. It results in the induction of electric current in the loop. According to the Lenz's law, the current produces the magnetic field of the opposite direction to the external field whose flux is increasing. Therefore, the direction of the induced current is clockwise.

11. **(b)** : From the slopes on the graph, we can obtain the ratio of accelerations of the two cyclists: $a_2/a_1 = 4$. The distances traveled by the two cyclists must be equal

$$\frac{a_1 t^2}{2} = \frac{a_2(t-3)^2}{2}; \frac{a_2}{a_1} = \left(\frac{t}{t-3}\right)^2;$$

$\frac{t}{t-3} = 2;\ \Rightarrow\ t = 6\,\text{min}$

12. (b) : The uniform motion with the terminal velocity is possible when the force of gravity of the object is equal to the force of the air resistance.

$$Mg = kv^2\frac{\pi d^2}{4}.$$

$$D\frac{\pi d^3}{6}g = kv^2\frac{\pi d^2}{4} \qquad \text{...(i)}$$

where M is the mass of a sphere, d is its diameter, D is the density of the material of the sphere, v is the velocity, and k is the constant coefficient for both spheres. From the equation (i), v is proportional to $\sqrt{d}$.

13. (b)

14. (b) : The horizontal segment of the graph corresponds to the melting of the solids. Under the same condition, the two identical masses have different time of phase transition. The time of the second object is greater, therefore, its latent heat is also greater.

(d) Comparing the slopes of the diagrams for the solid state of the two objects, we see that the same heat causes less change of temperature for the second object. Hence, the second object has the greater specific heat capacity.

15. (d) : The angle of incidence of the initial ray on the inclined side of the prism is less than the critical angle, therefore, the Snell's law gives the possibility for the ray to be refracted in the direction of the ray 2. In addition, there is also a possibility of reflection along ray 3.

16. (a) : The intensity of sound is increasing because the distance between the source and the observer is decreasing. Because the source is approaching the observer, the frequency increases due to Doppler effect.

17. (a) : Each conductor is parallel to the direction of magnetic field lines of another conductor. If the wire with current is parallel to the magnetic field line, the sine of the angle between this two directions is zero, and the magnetic force on the wire is zero.

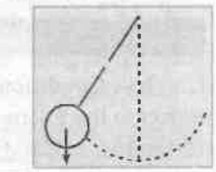
18. (c) : The pressure P of water on the base of the aquarium is given by: $P = DgH$, where D is the density of water, H is the height of the wall. Pressure is a linear function of the height. Therefore, the average pressure is half of the maximum one. The force on the lateral wall can be found from: $F = P_{av}HL$, where L is the length of the wall.

$$F = [(1000 \times 10 \times 0.3) / 2] \times 0.3 \times 0.4 = 180\ \text{N}.$$

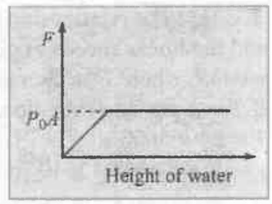
19. (b) : In the circular motion around the Earth, the centripetal force on the satellite is a gravitational force. Therefore, $v^2 = GM/R$, where M is the mass of the Earth, R is the radius of the Earth and G is the universal gravitational constant. Therefore, the kinetic energy increases with the decrease in the radius of the orbit. The gravitational potential energy is negative and decreases with the decrease in radius, i.e. the magnitude increases and it is negative.

20. (d) : The lines of field of the point charge are everywhere perpendicular to the surface of the conductive plane. The pattern of the electric field lines over the plane is absolutely the same as for the system of two identical and oppositely charged particles separated by the distance $2h$. Therefore, we can apply the Coulomb's law to calculate the force.

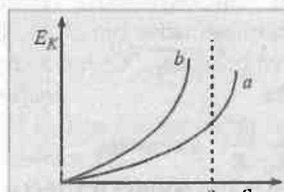
21. The motion will be vertically down under the force of gravity. No other forces are applied to the bob.



22. The force will increase linearly until the pressure of water under the piston becomes equal to the atmospheric pressure P_0. After this moment, the force becomes constant.

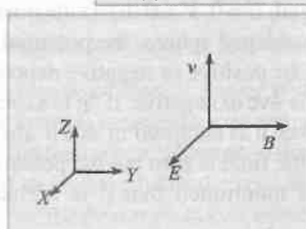


23. $c = 3 \times 10^8$ m/s



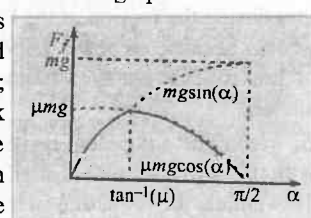
(a) Classical Mechanics
(b) Relativistic Mechanics

24.



25. There are two segments of the graph:

1. When the brick is motionless, and static friction exists;
2. When the brick moves and the force of kinetic friction acts on it. The motion starts when $\alpha = \tan^{-1}(\mu)$



(i) For the motionless brick: $F_f = mg\sin(\alpha)$

(ii) For the moving brick: $F_{fk} = \mu mg\cos(\alpha)$

26. Introducing the vertical and horizontal axes of coordinates, we can find the rate of change of the x-component of momentum for the sand.

(i) $\dfrac{\Delta p_x}{\Delta t} = \dfrac{(5.00\text{ kg})(0.750\text{ m/s})}{1.00\text{ s}} = 3.75\text{ N}.$

This change occurs due to the only horizontal force on the sand

The force of friction: $f = \dfrac{\Delta p}{\Delta t} = 3.75\text{ N}$

(ii) The belt is in equilibrium. It experiences the external force and the force of friction from the sand

$\sum F_x = ma_x \quad +F_{\text{ext}} - f = 0; \quad F_{\text{ext}} = 3.75\text{ N}$

(iii) $W = F\Delta r\cos\theta = 3.75\text{ N }(0.750\text{ m})\cos 0^\circ = 2.81\text{ J}$

(iv) $\dfrac{1}{2}(\Delta m)v^2 = \dfrac{1}{2}5.00\text{ kg}(0.750\text{ m/s})^2 = 1.41\text{ J}$

(v) Friction between the sand and the belt converts half of the input work into internal energy of both objects.

27. (i) The power, delivered to a resistor, is given by

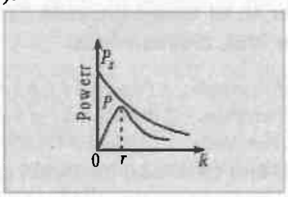
$P = \dfrac{E^2}{(R+r)^2}R$. This function has a maximum at $R = r$.

$P_{\max} = E^2/(4r)$.

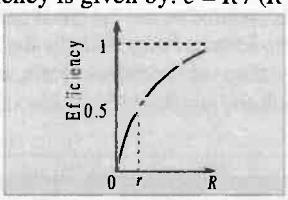
(ii) The power, produced by the source is

$P_s = \dfrac{E^2}{(R+r)^2}(R+r) = \dfrac{E^2}{(R+r)}$. This function is steadily decreasing with increasing of the resistance R (when $R = 0$, $P_S = E^2/r$).

(iii)



(iv) The efficiency is given by: $e - R/(R + r)$



28. (i) First, we must investigate the trajectory of the image of the source of light. The path AB of the source during some time interval is shown on the figure 1 as an object. Its image $A'B'$ is a trajectory of the image of the point source of light during the same time interval.

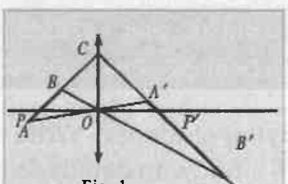


Fig. 1

Due to the properties of the point at the double-focal distance from the lens, the image of the object is also at the double-focal distance from the lens. Therefore, the trajectory of the image of the source of light $A'B'$ crosses the optical axis at the point P' at the distance $2F$ from the lens. The triangles POC and $P'OC$ are equivalent right angle triangles, and thus, the trajectory of the source and the trajectory of its image cross the optical axis of the lens under the same angle α. The diagram shows the different distances AB and $A'B'$, covered by the source and its image during the same time interval, which permits to state that the speeds of the source and the image are different.

(ii) While the object moves at the velocity v_0, its image moves at the velocity $\boldsymbol{u}$ along the line that crosses the optical axis at distance $2F$ from the vertex of lens and has the same magnitude of inclination α to the axis (figure 2).

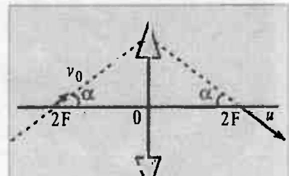


Fig. 2

(iii) The vector diagram of the velocities (figure 3) shows that the relative velocity $\boldsymbol{v}$ has its minimum magnitude when it is perpendicular to the vector $\boldsymbol{u}$. From this condition, we can obtain the result: $|\mathbf{v}|_{\min} = v_0\sin 2\alpha$. The obtained condition, however, does not permit us to conclude about the instantaneous position of the source of light at the moment that matches the result for the relative velocities, as it is clear from figure. The only general conclusion is that the position of the source must guaranty the following relationship between the instantaneous speed of the source and the instantaneous speed of its image: $v_0 < u$ ❖

Fig. 3

NEW PATTERN

Practice Paper IIT-JEE 2008

PHYSICS

SECTION - I
Only One Correct Option (Q. No. 1 to 5)

1. In gravity-free space, a man of mass M standing at a height h above the floor throws a ball of mass m straight down with a speed u relative to ground. When the ball reaches the floor, the distance of the man above the floor will be

(a) $h\left(1+\frac{m}{M}\right)$ (b) $h\left(2-\frac{m}{M}\right)$
(c) $2h$
(d) a function of m, M, h and u.

2. A solid cylinder of mass M and radius R is pulled by a horizontal force F acting at its topmost point on a horizontal surface where the coefficient of friction is μ. The maximum acceleration of the cylinder so that it may not start slipping is

(a) $2\mu g$ (b) $4\mu g$ (c) $\frac{2}{3}\mu g$ (d) $\frac{3}{2}\mu g$

3. Long glass capillary tube is dipped in water. It is known that water wets glass. The water level rises by h in the tube. The tube is now pushed down so that only a length $h/2$ is outside the water surface. The angle of contact of the water surface at the upper end of the tube will be

(a) 30° (b) 45° (c) $\tan^{-1}2$ (d) 60°

4. 1 g of water on evaporation at atmospheric pressure forms 1671 cm^3 of steam. Heat of vaporization at this pressure is 540 cal g^{-1}.The increase in internal energy is

(a) 250 cal (b) 500 cal
(c) 1000 cal (d) 1500 cal.

5. Two capacitors of 4 pF and 6 pF are connected in series and a potential difference of 5 kV is applied across the combination .They are then disconnected and reconnected in parallel. The potential difference across the combination is

(a) 1100 V (b) 2250 V (c) 2400 V (d) 1200V

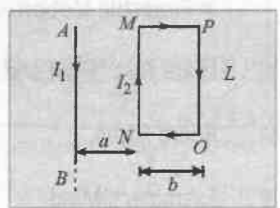
SECTION - II
One or More Correct Option (Q. No. 6 to 10)

6. A parallel plate capacitor is connected to a battery. The quantities charge, voltage, electric field and energy associated with this capacitor are given by Q_0, V_0, E_0 and U_0 respectively. A dielectric is now introduced between plates with battery still in connection. The corresponding quantities now are given by Q, V, E and U. These quantities are related to the previous ones as

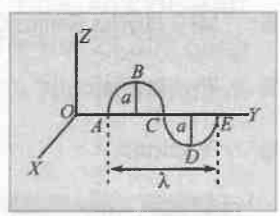
(a) $Q > Q_0$ (b) $V > V_0$ (c) $E > E_0$ (d) $U > U_0$

7. For the situation shown in the figure, the correct statement(s) is/are,

(a) The net force on the long straight wire AB is $F=\frac{\mu_0 I_1 I_2 L}{2\pi}\left[\frac{1}{a}-\frac{1}{a+b}\right]$ and is repulsive.
(b) The loop will be compressed.
(c) No torque will be acting on the loop as the forces are in same plane
(d) No torque will be acting on the loop as the forces experienced by the wires of the loop are normal to the plane of the loop.



8. The conductor $ABCDE$ has the shape shown in the figure. It lies in the yz- plane, with A and E on the y-axis. When it moves with a velocity v in a magnetic field B, an emf e is induced between A and E.



(a) $e = 0$, if v is in the y-direction and B is in the x-direction
(b) $e = 2Bav$, if v is in the y-direction and B is in the x-direction
(c) $e = B\lambda v$, if v is in the z-direction and B is in the x-direction.

(d) $e = B\lambda v$, if v is in the x-direction and B is in the z-direction.

9. A body of mass m is suspended from two light springs of force constants k_1 and k_2 ($< k_1$) separately. The periods of vertical oscillations are T_1 and T_2 respectively. Now the same body is suspended from the same two springs which are first connected in series and then in parallel. The period of vertical oscillations are T_s and T_p respectively

(a) $T_p < T_1 < T_2 < T_s$ for $k_1 > k_2$

(b) $\frac{1}{T_p^2} = \frac{1}{T_1^2} + \frac{1}{T_2^2}$ (c) $T_s^2 = T_1^2 + T_2^2$

(d) $\sqrt{T_s} = \sqrt{T_1} + \sqrt{T_2}$

10. Two different isolated coils have self-inductances, $L_1 = 8$ mH and $L_2 = 2$ mH. The current in one coil is increased at a constant rate. The current in the second coil is also increased at the same constant rate. At a certain instant of time, the power given to the two coils is the same. At that time the current, the induced voltage and the energy stored in the first coil are i_1, V_1 and U_1 respectively. Corresponding values for the second coil at the same instant are i_2, V_2 and U_2 respectively. Then,

(a) $\frac{i_1}{i_2} = \frac{1}{4}$ (b) $\frac{i_1}{i_2} = 4$ (c) $\frac{U_2}{U_1} = 4$ (d) $\frac{V_2}{V_1} = \frac{1}{4}$

SECTION - III

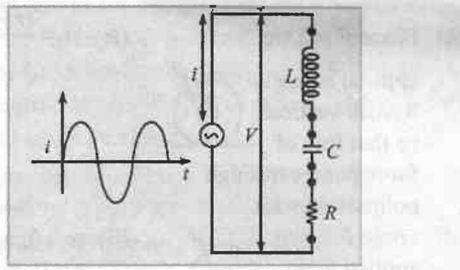
Match the Columns (Q. No. 61 to 64)

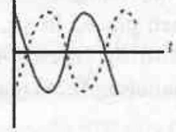
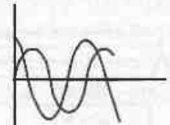
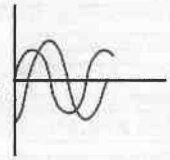
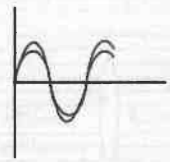
Statements in the Column - I (a, b, c, d) have to be matched with one or more statements in the Column - II (P, Q, R, S, T, U)

11. A parallel plate air capacitor has capacity 5×10^{-12} F. Plate A has a positive charge $q_1 = 10^{-10}$ coulomb and plate B has charge $q_2 = +2 \times 10^{-10}$ coulomb.

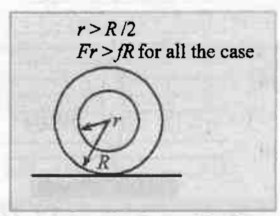
Column-I	Column-II
(a) charge on inner surface of plate A	(P) -50×10^{-12} F
(b) charge on outer surface of B is	(Q) 150×10^{-12} F
Now a cell of emf 10 V is connected	(R) 100×10^{-12} F
so that plate A is +ve and plate B –ve	(S) 50×10^{-12} F
(c) charge on inner surface of plate A is	(T) -100×10^{-12} F
(d) charge on outer surface of plate B is	(U) -150×10^{-12} F

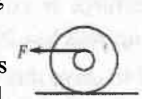
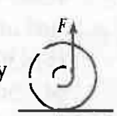
12. Figure shows an LCR circuit consisting of a series combination of a resistance R, an inductance L and a capacitance C driven by a current source. $i(t) = I_{max} \sin \omega t$. Match the graphs given in Column-II to element given in Column-I.



Column-I (Element)	Column-II (Graph of voltage and current
(a) Inductor	(P) 
(b) Capacitor	(Q) 
(c) Resistor	(R) 
(d) Plot of voltage across capacitor and inductor	(S) 

13. A heavy spool of mass M and radii r, R of axel and spool respectively is resting on rough surface so that only rolling may be possible. An ideal string is wound on the axel. The string is continuously pulled by applying force F. There is no slipping between string and axel. f stands for force of friction. Match the following. ($I = MR^2$)



Column-I	Column-II
(a) Force $F = $ Mg is applied to string towards left and spool rolls without slipping. 	(P) $\alpha = \frac{Mg(r+R)}{2MR^2}$
(b) Force $F = Mg$ is applied vertically upwards. 	(Q) $\alpha = \frac{Mg(r-R)}{2MR^2}$

(c) Force $F = 2Mg$ applied at angle θ_0 with vertical so that line of force passes through point of contact

(R) $\alpha = \frac{(r - R\sin\theta)}{R^2} g$

(d) Force $F = Mg$ applied at an angle $\theta < \theta_0$

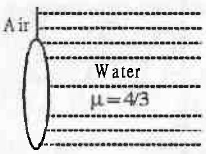
(S) $\alpha = 0, a_{cm} = 0$

(T) $\alpha \neq 0, a_{cm} = 0$

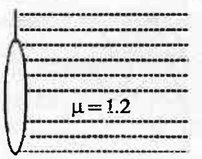
(U) $\alpha \neq 0, a_{cm} \neq 0$

14. A thin equiconvex lens ($\mu = 1.5$) has focal length 50 cm when placed in air. In column-I are given lens and surrounding medium. In column-II are given corresponding focal lengths.

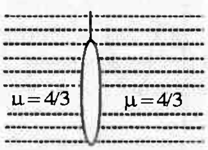
Focal length

(a) 

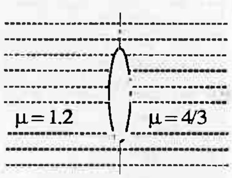
(P) 600 cm

(b) 

(Q) 100 cm

(c) 

(R) 75 cm

(d) 

(S) 143 cm

(T) 237 cm

(U) 200 cm

SECTION - IV

Comprehension Type (Q. No. 15 to 19)

Passage-I

When 2500 kg car driven at 72 km/hr on level road is put in neutral gear (engine force is cut off) the velocity decreases in the following way $v = 20/(1 + t/20)$.

15. The power required to drive this car at 36 km/hr is

(a) 2.5 kW (b) 3.0 kW

(c) 6.25 kW (d) 9 kW

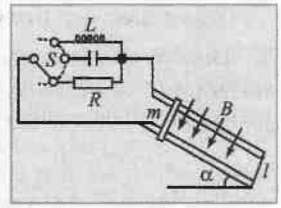
16. The resistive force at speed of 72 km/hr was

(a) 2500 N (b) 3000 N

(c) 4000 N (d) 5000 N

Passage-II

A homogenous field of magnetic induction B is perpendicular to a track of breadth l which is inclined at an angle α to the horizontal. A frictionless conducting rod of mass m slides the two rails of the track as shown in the figure.



17. When switch S connects capacitor C in circuit acceleration of rod after some time is

(a) zero

(b) constant and equal to $\frac{mg\sin\alpha}{m + B^2l^2C}$

(c) constant and equal to $\frac{mg\sin\alpha}{m - B^2l^2C}$

(d) increasing continuously

18. When switch S connects resistor R in circuit maximum velocity of rod is

(a) $\frac{Mg R\sin\alpha}{2B^2l^2}$ (b) $\frac{Mg R\sin\alpha}{B^2l^2}$

(c) $\frac{3Mg R\sin\alpha}{2B^2l^2}$ (d) $\frac{Mg R\sin^2\alpha}{B^2l^2}$

19. When switch S connects an inductor L, the rod

(a) reaches terminal velocity

(b) has constant acceleration

(c) has increasing acceleration

(d) oscillates simple harmonically

SECTION - V

Assertion & Reason (Q. No. 20 to 21)

Instructions : *Each question contains statement-1 (assertion) and statement-2 (reason). Of these statements, mark correct choice if*

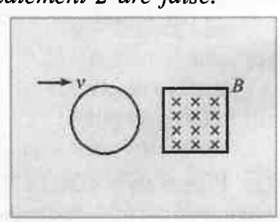
(a) statements-1 and 2 are true and statement-2 is a correct explanation for statement-1

(b) statements-1 and 2 are true and statement-2 is not a correct explanation for statement-1

(c) statement-1 is true, statement-2 is false

(d) both statement-1 and statement-2 are false.

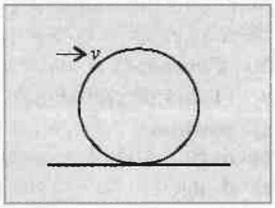
20. A man is moving with constant speed in A cart. A vertical coil of conducting wire with galvanometer is in a cart. The plane of coil is parallel to velocity (see figure). Uniform magnetic field B is as shown in the figure



Statement-1: When he crossed uniform magnetic field galvanometer shows deflection.

Statement-2: He states that current is produced because Lorentz force acts on free electrons.

21. Disc rests on rough horizontal surface. A particle of mass m strikes the disc tangentially at topmost point (see figure)



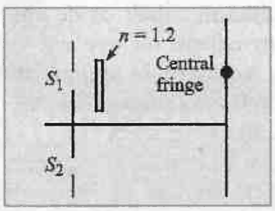
Statement-1: Angular momentum of system about point of contact is not conserved.

Statement-2: External torque due to friction acts on disc during collision.

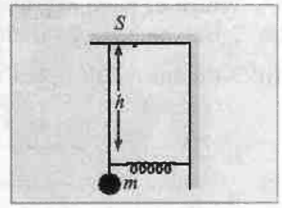
SECTION - VI

Subjective Questions (Q. No. 22 to 25)

22. A two-slit Young's experiment is illustrated in the figure $\lambda = 5000$ Å. When a thin film of a transparent material is put behind one of the slits, the zero order fringe moves to the position previously occupied by the 4th order bright fringe .The index of refraction of the film is $n = 1.2$. (a) Calculate the thickness of the film and (b) shift of central fringe if S_1S_2 is 1 mm, and distance between slit and screen is 2 m.



23. A simple pendulum of massless rod of length L and mass m has a spring of force constant k connected to it at a distance h below its point of suspension. Find the frequency of vibrations of the system for small values of amplitude.



24. A piston divides a closed gas cylinder into two parts. Initially the piston is kept pressed such that one part has a pressure P and volume $5V$ and the other part has pressure $8P$ and volume V; the piston is now left free. Find the new pressure for (a) the isothermal and (b) adiabatic process [$\gamma = 1.5$]

25. A body is projected vertically upwards from the surface of earth with a velocity sufficient to carry it to infinity. Calculate the time taken by it to reach height h.

CHEMISTRY

SECTION - I

Only One Correct Option (Q. No. 26 to 30)

26. The average energy of oscillator with frequency 10^{14} Hz at 1000 K is ....

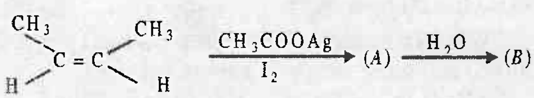
(Boltzmann constant = 1.38×10^{-23} J K^{-1})

(a) 5.55×10^{-22} J (b) 1.2×10^{-20} J
(c) 3.6×10^{4} J (d) 4.2×10^{-24} J

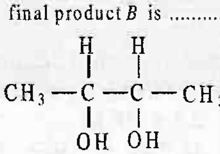
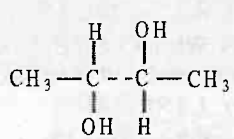
27. $A \rightarrow B$, fraction of A left undecomposed after 400 sec was 0.5 and after 964 sec, it was 0.25. The order of reaction was ....

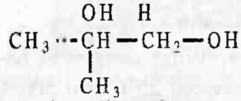
(a) 2 (b) 1.5 (c) 3.5 (d) 1st order

28.



final product B is ....

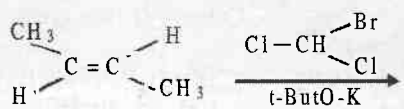
(a)  (b) 

(c) both (a) and (b) (c) 

29. If $18e^-$ rule is valid for Mn, Fe the value of x, y are .... in the $Mn_2(CO)x$, $Fe_3(CO)y$

(a) 3, 4 (b) 10, 12 (c) 5, 6 (d) 4, 6

30.



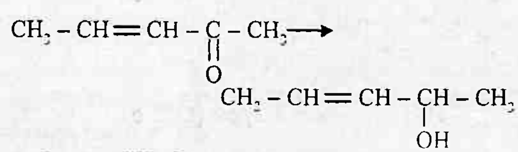
product has .... isomers

(a) none (b) 2 (c) 3 (d) 4

SECTION - II

One or More Correct Option (Q. No. 31 to 35)

31.



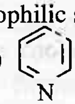
conversion possible by .... reagents

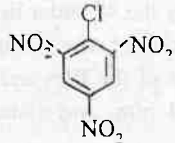
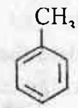
(a) $LiAlH_4$ (b) Zn . Hg/HCl
(c) $NaBH_4$ (d) Al-Isopropoxide

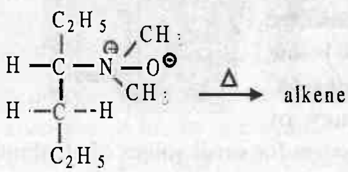
32. $Re_2Cl_8^{--}$ molecule has

(a) σ bonds (b) dp hybridization
(c) δ bond (d) bond order is three

33. Which can undergo nucleophilic substitution?

(a) C_2H_5Br (b) 

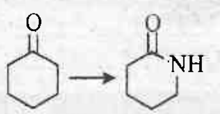
(c)  (d) 

34. Which of these can form trans-product ?
(a) 2-Butyne + H_2-Pd/$BaSO_4$ $\rightarrow$ alkene
(b) 2-Butene (cis) + $C_6H_5CO_3H \rightarrow (A) \xrightarrow{H_3O^+} (B)$ diol
(c) 
(d) trans-2-pentene + $OsO_4 \longrightarrow (A) \xrightarrow{H_3O^+}$ diol

35. Solubility of $PbCl_2$......
(a) decreases in 0.1 M KCl
(b) increases in 1M CN^-
(c) decreases by increasing temperature
(d) decreases by adding $C_2O_4^{--}$

SECTION - III
Match The Columns (Q. No. 36 to 39)

Statements in the Column - I (a, b, c, d) have to be matched with one or more statements in the Column - II (P, Q, R, S, T, U)

36. **Column-I (Conversions)** — **Column-II (Reagents)**
(a) $>C=O \rightarrow >CH_2$ — (P) H_2NOH/dil. H_2SO_4
(b) $CO_2 \rightarrow H_2C_2O_4$ — (Q) Zn . Hg/HCl
(c) $CH_2=CH-CHOH-CH_3$ $\downarrow$ $CH_2=CH-\overset{O}{\overset{\|}{C}}-CH_3$ — (R) N_2H_4 / OH^-
(S) Na at 230°C
(T) PCC, CH_2Cl_2
(d)  — (U) $K_2Cr_2O_7$

37. **Column-I (Molecule)** — **Column-II (Property)**
(a) F_2 — (P) π Bond order is 2
(b) C_2 — (Q) Hydration energy maximum
(c) KO_2 — (R) Paramagnetic
(d) NO — (S) Odd electron molecule
(T) oxidising property

38. **Column-I (Pairs of compounds)** — **Column-II (Method of separation)**
(a) *o*, *p*-Nitrophenols — (P) Benzene
(b) *d*(+), *l*(+) 2-Butanol — (Q) Steam distillation
(c) AgCl, AgI — (R) Chromatography
(d) $AlCl_3$, $MgCl_2$ — (S) NH_3
(T) $C_2H_5-O-C_2H_5$ ether

39. **Column-II (Types of emission)** — **Column-I (Isotope)**
(a) positron — (P) ${}_{94}Pu^{239}$
(b) α, β — (Q) ${}_{6}C^{14}$
(c) β-rays — (R) ${}_{6}C^{11}$
(d) X-rays — (S) ${}_{14}Si^{30}$
(T) ${}_{24}Cr^{55}$
(U) ${}_{7}N^{13}$

SECTION - IV
Comprehension Type (Q. No. 40 to 44)

Passage-I

Lithium cobalt oxide and specially carbon are active ingredients for +ve and –ve electrodes, respectively for a rechargeable lithium battery. During charge recharge cycles, following half cell reaction occur

$LiCoO_2 \rightleftharpoons Li_{1-n} + CoO_2 + x\,.\,Li^{\oplus} + x\,e^{\ominus}$

$C + x\,Li^+ + 2e^-\,C \rightleftharpoons Li_x$

total amount of energy battery can store is rated as mA hr. Battery rated as 1500 mA hr can power a device drawing 100 mA current for 15 hrs. Graphite has lithium inter colation sites between its layers.

40. If carbon Li intercolation ratio is 6 : 1 the theortical charge capacity of 1gm graphite to intercolate lithium is ....
(a) 372 mA hr/gm (b) 684 mA hr/gm
(c) 150 mA hr/gm (d) 880 mA hr/gm

41. 1 gm graphite can charge .... coulombs
(a) 1341 (b) 95600 (c) 13600 (d) 2682

Passage-II

Hydrogen is more energy dense than carbon by mass. It is very powerful fuel and can operate the heat engine. $S°(H_2) = 131\ Jmol^{-1}K^{-1}$, $S°(O_2) = 205\ Jmol^{-1}K^{-1}$, $S°(H_2O) = 20\ Jmol^{-1}K^{-1}$)

42. What is the ratio between heat generated by hydrogen burned and same weight of carbon burned ?
$\Delta H_f\ H_2O = -286$ kJ $\quad \Delta H_f\ CO_2 = -394$ kJ
(a) 2.2 (b) 4.3 (c) 6.8 (d) 12.6

43. When 1 kg of H_2 is burned, find theoretical maximum work produced from electric motor. Using H_2 as fuel ?
(a) 1.2×10^5 kJ (b) 2.4×10^5 kJ
(c) 8.6×10^4 kJ (d) 11.2 kJ

44. What work will be provided by engine operating between 25°C and 300°C ?
(a) 6.9×10^4 kJ (b) 2.4×10^5 kJ
(c) 6.2×10^2 kJ (d) 182 kJ

SECTION - V
Assertion & Reason (Q. No. 45 to 46)

Instructions : *Each question contains statement-1 (assertion) and statement-2 (reason). Of these statements, mark correct choice if*

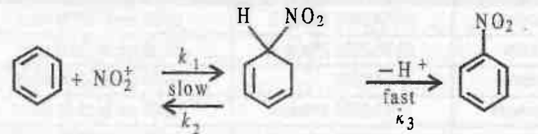
(a) statements-1 and 2 are true and statement-2 is a correct explanation for statement-1
(b) statements-1 and 2 are true and statement-2 is not a correct explanation for statement-1
(c) statement-1 is true, statement-2 is false
(d) both statement-1 and statement-2 are false.

45. Statement-1: I.P. N_2 > I.P. of O_2
Statement-2: N_2 looses bonding e^- and O_2 looses antibonding e^-

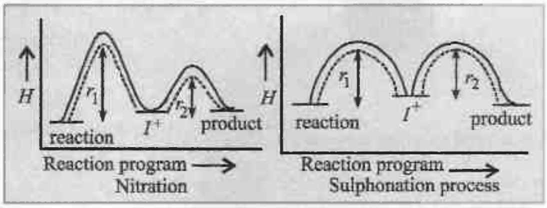
46. Statement-1: CH_3CN less basic than $CH_3-CH=NH$
Statement-2: Triple bond N has more I.P. than double bond N.

SECTION - VI
Subjective Questions (Q. No. 47 to 50)

47. Compound (A) $C_7H_7O_2N$ is insoluble dil HCl/NaOH. It does not react with Benzene sulphonyl chloride or acetylchorides. On reduction, with Zn + NH_4Cl. It forms (B), C_7H_9ON which forms silver mirror with Tollen's reagent, and oxidized product (C) C_7H_7ON. The compound (C) can form isomers X and Y on nitration with con. HNO_3. Find st. of A, B, C, X, Y explain the reaction.

48. 

Nitration of Benzene takes place by above path. k_1, k_2, k_3 rate constants sulphonation also takes place by same steps. (k_1', k_2', k_3' rate constant). Graph of Benzene and C_6D_6 (deutro benzene) are shown in nitration and sulphonation in figure-1 and 2 ($-C_6D_6$) (...... C_6H_6). Explain the effect in benzene and C_6D_6 by using calculate of k_1, k_2, k_3 nitration graph



Compare rate of Nitration use of Benzene/C_6D_6 (k_1, k_2, k_3)
Compare rate of Sulphonation of Benzene/C_6D_6 (k_1', k_2', k_3')

49. It is possible to prevent precipitate of $Co(OH)_3$ from solution of 0.01M $CoCl_3$ by buffering solution at pH 9.1 with buffer having NH_3 and NH_4^+ ion. How much of 6 M NH_3 and 6M HCl should be added per litre of this solution to prevent $Co(OH)_3$ from precipitate ?
(k_b $NH_3 = 2 \times 10^{-5}$, k_{sp} $Co(OH)_3 = 10^{-43}$, k_f for $Co(NH_3)^{3+} = 2 \times 10^{35}$)

50. A cell is prepared $M \left| \begin{matrix} MCl \\ 1\times10^{-4}M \\ NH_3(2M) \end{matrix} \right\| \begin{matrix} MCl \\ 1\times10^{-2}M \\ NH_3(2M) \end{matrix} \Big| M$

where MCl is insoluble salt which form complex $Mx(NH_3)_y$ with NH_3. E_{cell} was 0.118 volts at 25°C.

Another cell is $M \left| \begin{matrix} MCl \\ 1\times10^{-5}M \\ NH_3(0.01M) \end{matrix} \right\| \begin{matrix} MCl \\ 1\times10^{-5}M \\ NH_3(0.1M) \end{matrix} \Big| M$ it has emf 0.1179 volts at 25°C. Find value of x, y (formation of complex) [$xM^+ + y\,NH_3 \rightleftharpoons M_x(NH_3)_y$ complex]

MATHEMATICS

SECTION - I
Only One Correct Option (Q. No. 51 to 55)

51. If α is a root of $x^2 + ax + b = 0$ then α^2 is also its root. Let a, b be real, then the number of such quadratic equations is (are)

(a) one (b) two
(c) three (d) infinitely many

52. The minimum distance of $x^2 - 2y^2 = 1$ from the line $y = x$ is

(a) $\sqrt{2}$ (b) $1/\sqrt{2}$ (c) $2\sqrt{2}$ (d) 1/2

53. Which of the following relation represents a hyperbola in (x, y) plane

(a) $13x = 15y - 3 \pm \sqrt{(y-7)(y+5)}$
(b) $15y = 13x - 3 + \sqrt{(x-3)(2-x)}$
(c) $15x = 13y + 3 \pm \sqrt{5x-2y+7}$
(d) $13x = 15y + 3 \pm \sqrt{-3+x-4x^2}$

54. Which of the following expressions will NOT admit 2 as a value?

(a) $|Z-2|$ (b) $|Z-1| + |Z+1|$
(c) $|Z-1| + |Z-2| + |Z+3|$
(d) $|2Z+1| + |Z| + |Z-1|$

55. The digits 1, 2, 3, ..., 9 are written in random order to forms a nine digit number. In this how many numbers will be divisible by 11 ......

(a) $11 \times 4!\,5!$ (b) $11 \times 2! \times 7!$
(c) $11 \times 3!\,6!$ (d) $11 \times 9!$

SECTION - II
One or More Correct Option (Q. No. 56 to 60)

56. The function(s) having a maximum or a minimum is (are)

(a) $57 - (1 - x)^{19}$ (b) $54 - (1 - x)^{28}$

(c) $x^{17} + x^9 + 2x + 1$ (d) $|x - 8|$

57. The limit(s) that do(es) not exist are

(a) $\lim\limits_{x \to 0} (1 - x)^{1/x^2}$ (b) $\lim\limits_{x \to 0} (1 - x^2)^{1/x^2}$

(c) $\lim\limits_{x \to 0} (1 - x^2)^{1/x}$ (d) $\lim\limits_{x \to 0} (x - \sin x)^{\cot^2 x}$

58. The sum(s) equaling 4^n are

(a) $\sum\limits_{k=0}^{2n} \binom{n}{k}$ (b) $2\sum\limits_{k=0}^{n} \binom{2n}{2k}$ (c) $2\sum\limits_{k=0}^{n} \binom{2n}{k}$ (d) $\sum\limits_{k=0}^{n} \binom{2n+1}{k}$

59. A circle keeps touching the x-axis and the circle $x^2 + (y - 2)^2 = 4$ externally. The locus/loci of centers of such circles

(a) one ray (b) one parabola

(c) two parabolas (d) one circle

60. If $\sin 2x > \cos x$ and $x \in [-\pi, \pi]$, then $x \in$

(a) $[-\pi, \pi/2]$ (b) $[\pi/6, \pi/2]$

(c) $[5\pi/6, \pi]$ (d) $[\pi/2, 5\pi/6]$

SECTION - III
Match The Columns (Q. No. 61 to 64)

61. Let $a_0, a_1, a_2, \ldots\ldots$ and $b_0, b_1, b_2, \ldots\ldots$ be non-zero real numbers. Using the concept of infinite GP, Match the following for the valid type of expansion of

$$f(x) = \frac{1}{x^2 - 8x + 15}$$

Column-I	Column-II
(a) for $x > 6$	(P) $\sum\limits_{n=0}^{\infty} a_n x^n$
(b) for $-1 < x < 1$	(Q) $\sum\limits_{n=0}^{\infty} b_n x^{-n}$
(c) for $x < 2$	(R) $\sum\limits_{n=0}^{\infty} (a_n x^n + b_n x^{-n})$
(d) for $3 < x < 5$	(S) none of these

62. Vectors $\overline{OA}, \overline{OB}, \overline{OC}$ are such that $3\overline{OA} + 4\overline{OB} + 6\overline{CO} = 0$, also $\overline{OA}$ is not proportional to $\overline{OB}$. Match the following

Column-I	Column-II
(a) The points A, B, C will form a triangle.	(P) True
(b) The vectors $\overline{OA}, \overline{OB}, \overline{OC}$ will form a triangle.	(Q) False
(c) Any other vector can be written as a linear combination of $\overline{OA}, \overline{OB}, \overline{OC}$	
(d) $OABC$ will be a quadrilateral.	

63. If $\sin\theta = \dfrac{\sqrt{4 - x^2}}{1 - x}$, and u, v ($u < v$) are the roots of $2x^2 - 2x - 3 = 0$, then Match the following

Column-I	Column-II
(a) $x \in [-2, -1]$	(P) $0 \in [0, \pi/3]$
(b) $x \in (-1, u)$	(Q) $\theta \in (\pi/3, \pi/2)$
(c) $x \in (0, 1)$	(R) $\theta \in (-\pi/2, 0)$
(d) $x \in (v, 2)$	(S) null set

64. Let $f(x)$ be differentiable in $[-4, 4]$ and $f(-1) = 0$, $f(1) = 4$, $f(2) = -4$, then Match the following where prime denotes differentiation w. r. t. x.

Column-I	Column-II
(a) The least number of real root(s) of $f(x) = 0$ in $[-2,2]$ (is) are	(P) one
(b) The least number of real root(s) of $f'(2x + 1) = 0$ in $[-3/2, 5/2]$ (is) are	(Q) two
(c) The least number of real root(s) of $f(x^2) = 0$ in $[-\sqrt{3}, \sqrt{3}\,]$ (is) are	(R) three
(d) The least number of real root(s) of $f'(-x^2) = 0$ in $[-\sqrt{2}, \sqrt{2}\,]$ (is) are	(S) none

SECTION - IV
Comprehension Type (Q. No. 65 to 69)

Passage-I

The mid points (P_n) of all the chords of $C : x^2 + y^2 = 1$ passing through the point $Q(0, 2)$ are joined with the point $R(1, 1)$. Let (Γ) be the curve where the mid points of P_nR will lie.

65. The equation of Γ is

(a) $x^2 + y^2 - x - 2y + 1 = 0$ (b) $x^2 + y^2 + x - 2y + 1 = 0$

(c) $x^2 + y^2 - x - 2y - 1 = 0$ (d) $x^2 + y^2 - x + 2y - 1 = 0$

66. The equation of one of the common tangents of C and Γ is

(a) $4y = -3x + 5$ (b) $4y = 3x + 5$

(c) $3x = 4y + 5$ (d) $3x = 4y - 6$

67. The equation of the chord of contact of C corresponding to the common tangents is

(a) $x - 2y = 1$ (b) $x - 2y + 1 = 0$

(c) $x + 2y = 1$ (d) $x + 2y + 1 = 0$

Passage-II

If $f(x)=\dfrac{x|x|}{1+x}\ \forall\ x>-1$.

68. $f^{-1}(x)=$

(a) $\dfrac{x-\sqrt{x^2+4x}}{2},\ x<0$ (b) $\dfrac{-x+\sqrt{x^2+4x}}{2},\ x>0$

(c) $\dfrac{|x|+\sqrt{x^2+|4x|}}{2}$ (d) $\dfrac{|x|+\operatorname{sgn}(x)\sqrt{x^2+|4x|}}{2}$

69. The number of real roots of the equation $f(x)=f^{-1}(x)$ are

(a) none (b) one

(c) two (d) more than two

SECTION - V

Assertion & Reason (Q. No. 70 to 71)

Instructions : *Each question contains statement-1 (assertion) and statement-2 (reason). Of these statements, mark correct choice if*

(a) statements-1 and 2 are true and statement-2 is a correct explanation for statement-1

(b) statements-1 and 2 are true and statement-2 is not a correct explanation for statement-1

(c) statement-1 is true, statement-2 is false

(d) both statement-1 and statement-2 are false.

70. In triangle ABC, if $a=2$, $b=2k$ and $\angle A=\pi/3$.

Statement-1: Two triangles are possible if $1<k<2/\sqrt{3}$.

Statement-2: A quadratic equation $px^2+qx+r=0$ has two real and distinct positive roots if $q^2>pr$ and $\dfrac{-q}{p}>0$, and $\dfrac{r}{p}>0$.

71. Let $f(x)=\sin 3x\, e^{-\sin x}$

Statement 1: The limit of $f(x)$ as $x\to\infty$ does not exist.

Statement 2: If there exists a pair of sequences x_n and x'_n having limiting values and $x_\infty=a=x'_\infty$ and if $f(x_n)\neq f(x'_n)$ then the limit of $f(x)$ as $x\to a$ does not exist. (Hint: the sequence $x_n=n\pi+\alpha$ is such that $x_\infty=\infty$ and $x_n=1/n\pi$ is such that $x_\infty=0$).

SECTION - VI

Subjective Questions (Q. No. 72 to 75)

72. If $n\geq 1$ and $f(n)=\dfrac{1}{1^2}+\dfrac{1}{2^2}+\dfrac{1}{3^2}+......\dfrac{1}{n^2}$. Find least positive integers a and b such that $a<f(n)<b$.

73. Let $0<a<2b$. Find the least and the greatest values of $\dfrac{a}{a+2b}+\dfrac{2b}{3a+4b}$.

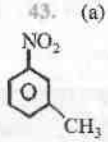
74. If θ is real then find the loci of a focus and of a vertex of the family of conics

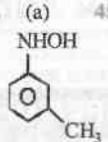
$$y^2-4x-6y\cos\theta+16\sin\theta+9\cos^2\theta+4=0.$$

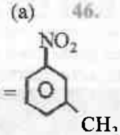
75. Check that the equation $|Z+1/Z|=1/2$ represents two branches of bounded curves in the Argand plane, find the minimum and maximum distance between them.

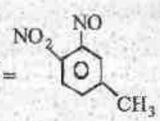
ANSWERS

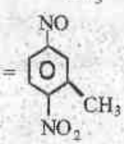
1. (a) 2. (b) 3. (d) 4. (b) 5. (d)
6. (a,d) 7. (a, c) 8. (a, c, d)
9. (a, b, c) 10. (a, c, d)
11. a-P, b-Q, c-S, d-Q
12. a-Q, b-R, c-S, d-P
13. a-P,U, b-T, c-R, d-U
14. a-Q, b-R, c-U, d-S 15. (c) 16. (a)
17. (b) 18. (b) 19. (d) 20. (b) 21. (d)
22. (a) 10×10^{-6} m, (b) 0.40×10^{-4} m or 4 mm
23. $f=\dfrac{1}{2\pi}\sqrt{\dfrac{mgL+kh^2}{mL^2}}$
24. (a) $(13/6)P$, (b)1.84 P or $\sqrt{27/8}P$ or $(3\sqrt{3}/2\sqrt{2})P$
25. $t=\dfrac{1}{3}\sqrt{\dfrac{2R}{g}}\left[\left(1+\dfrac{h}{R}\right)^{3/2}-1\right]$ 26. (a) 27. (b)
28. (a) 29. (b) 30. (b) 31. (a, c, d)
32. (a, b, c) 33. (a, b, c)
34. (b, d) 35. (a, b, c)
36. a-Q,R, b-S, c-T, d-P
37. a-Q, T, b-P, c-R, d-R,S
38. a-Q, b-R, c-S, d-P,T
39. a-R,U, b-P, c-Q, d-T 40. (a) 41. (a)
42. (b) 43. (a) 44. (a) 45. (a) 46. (c)
47.

$A=$ 

$B=$ 

$C=$ 

$X=$ 

$Y=$ 

48. Nitrate RC_6H_6 = RC_6D_6, Sulphonation $RC_6H_6 > RC_6D_6$
49. NH_3 = 30 ml, HCl = 12 ml
50. $x=1,\ y=2$ 51. (c) 52. (b) 53. (a)
54. (c) 55. (a) 56. (b, d) 57. (a, d)
58. (b, d) 59. (a, c) 60. (a, b, c)
61. a-Q, b-P, c-P, d-R
62. a-P, b-Q, c-Q, d-P
63. a-P, b-Q, c-S, d-R
64. a-Q, b-P, c-Q, d-P 65. (a) 66. (b)
67. (c) 68. (d) 69. (c) 70. (a) 71. (d)
72. $a=1,\ b=2$ 73. $\min=\dfrac{1}{2},\ \max=\dfrac{7}{10}$
74. $\dfrac{(x-1)^2}{16}+\dfrac{y^2}{9}=1,\ \dfrac{(x-2)^2}{16}+\dfrac{y^2}{9}=1$
75. $\dfrac{\sqrt{17}+1}{2},\dfrac{\sqrt{17}-1}{2}$

Exam on 27.04.2008

Practice Paper
AIEEE - 2008

PHYSICS

1. The masses and radii of the earth and moon are M_1, R_1 and M_2, R_2 respectively. Their centres are a distance d apart. The minimum speed with which a particle of mass m should be projected from a point midway between the two centres so as to escape to infinity is given by

(a) $2\left[\frac{G(M_1+M_2)}{md}\right]^{1/2}$ (b) $2\left[\frac{G(M_1+M_2)}{d}\right]^{1/2}$

(c) $2\left[\frac{G(M_1-M_2)}{md}\right]^{1/2}$ (d) $2\left[\frac{G(M_1-M_2)}{d}\right]^{1/2}$

2. If M is the mass of the earth, R its radius (assumed spherical) and G the universal gravitational constant, then the amount of work that must be done on a body of mass m so that it completely escapes from the gravity of the earth, is given by

(a) $\frac{GmM}{R}$ (b) $\frac{GmM}{2R}$

(c) $\frac{3GmM}{2R}$ (d) $\frac{3GmM}{4R}$

3. A rocket is fired from the earth to the moon. The distance between the earth and the moon is r and the mass of the earth is 81 times the mass of the moon. The gravitational force on the rocket will be zero, when its distance from the moon is

(a) $\frac{r}{20}$ (b) $\frac{r}{15}$ (c) $\frac{r}{10}$ (d) $\frac{r}{5}$

4. A hydraulic lift is used to lift a car of mass 3000 kg. The cross-sectional area of the lift on which the car is supported is 5×10^{-2} m. What is the pressure on the smaller piston, if both the pistons are at the same horizontal level ? Take $g = 10$ ms^{-2}.

(a) 6×10^5 Pa (b) 5×10^5 Pa

(c) 4×10^5 Pa (d) 3×10^5 Pa

5. A block of wood floats in a liquid with four fifths of its volume submerged. If the relative density of wood is 0.8, what is the density of the liquid in units of kg m^{-3} ?

(a) 750 (b) 1000 (c) 1250 (d) 1500

6. A rectangular tank is filled to the brim with water. When a hole at its bottom is unplugged, the tank is emptied in time T. If the tank is half-filled with water, it will be emptied in time

(a) $\frac{T}{\sqrt{2}}$ (b) $\frac{T}{\sqrt{3}}$ (c) $\frac{T}{2}$ (d) $\frac{T}{2\sqrt{2}}$

7. At 40°C, a brass rod has a length 50 cm and a diameter 3.0 mm. It is joined to a steel rod of the same length and diameter at the same temperature. What is the change in the length of the composite rod when it is heated to 240°C ? The coefficients of linear expansion of brass and steel are 2.0×10^{-5} °C^{-1} and 1.2×10^{-5} °C^{-1} respectively.

(a) 0.28 cm (b) 0.30 cm

(c) 0.32 cm (d) 0.34 cm

8. Two rods of different materials having coefficients of thermal expansion α_1 and α_2 and Young's moduli Y_1 and Y_2 are fixed between two rigid and massive walls. The rods are heated to the same temperature. If there is no bending of the rods, the thermal stresses developed in them are equal provided.

(a) $\frac{Y_1}{Y_2} = \sqrt{\frac{\alpha_1}{\alpha_2}}$ (b) $\frac{Y_1}{Y_2} = \sqrt{\frac{\alpha_2}{\alpha_1}}$

(c) $\frac{Y_1}{Y_2} = \frac{\alpha_1}{\alpha_2}$ (d) $\frac{Y_1}{Y_2} = \frac{\alpha_2}{\alpha_1}$

9. A copper block of mass 2 kg is heated to a temperature of 500°C and then placed in a large block of ice at 0°C. What is the maximum amount of ice that can melt ? The specific heat of copper is 400 J kg^{-1} °C^{-1} and latent heat of fusion of water is 3.5×10^5 J kg^{-1}.

(a) $\frac{4}{3}$ kg (b) $\frac{6}{5}$ kg (c) $\frac{8}{7}$ kg (d) $\frac{10}{9}$ kg

10. A person measures the time period of a simple pendulum inside a stationary lift and finds it to be T. If the lift starts accelerating upwards with an acceleration of $g/3$, the time period of the pendulum will be

(a) $\sqrt{3}T$ (b) $\frac{\sqrt{3}T}{2}$ (c) $\frac{T}{\sqrt{3}}$ (d) $\frac{T}{3}$

Contributed by : Momentum, 1495, Near Stadium, Wright Town, Jabalpur Ph.: 4005358, 4035241.

11. Two identical waves, each of frequency 10 Hz, are travelling in opposite directions in a medium with a speed of 20 cm s^{-1}. The distance between adjacent nodes is

(a) 1.0 cm (b) 1.2 cm (c) 1.5 cm (d) 2.0 cm

12. Two parts of a sonometer wire, divided by a movable knife-edge, differ in length by 1 cm and produce 1 beat per second when sounded together. If the total length of the wire is 100 cm, the frequencies of the two parts of the wire are

(a) 51 Hz, 50 Hz (b) 50.5 Hz, 49.5 Hz
(c) 49 Hz, 48 Hz (d) 49.5 Hz, 48.5 Hz

13. How is the interference pattern in Young's double slit experiment affected if the sodium (yellow) light is replaced by red light of the same intensity ?

(a) The fringes will vanish
(b) The fringes will become brighter
(c) The fringe width will decrease
(d) The fringe width will increase

14. In Young's double slit experiment, the slits are separated by 0.28 mm and the screen is placed 1.4 m away. The distance between the fourth bright fringe and the central bright fringe is measured to be 1.2 cm. What is the wavelength of light used in the experiment ?

(a) 200 nm (b) 400 nm (c) 600 nm (d) 800 nm

15. In Young's double slit experiment the slits are 0.5 mm apart and interference is observed on a screen placed at a distance of 100 cm from the slits. It is found that the 9th bright fringe is at a distance of 9.0 mm from the second dark fringe from the centre of the fringe pattern. What is the wavelength of light used ?

(a) 2000 Å (b) 4000 Å (c) 6000 Å (d) 8000Å

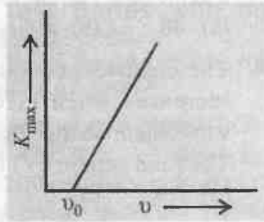
16. In a cathode ray tube, the electrons are subjected to a potential difference of 182 V. The maximum speed acquired by the electrons is

(a) 10^6 ms^{-1} (b) 2×10^6 ms^{-1}
(c) 4×10^6 ms^{-1} (d) 8×10^6 ms^{-1}

17. In Millikan's oil drop experiment, a charged oil drop of mass 3.2×10^{-14} kg is held stationary between two parallel plates 6 mm apart by applying a potential difference of 1200 V between them. How many excess electrons does the oil drop carry ? Take $g = 10$ ms^{-2}

(a) 7 (b) 8 (c) 9 (d) 10

18. The maximum energy K_{max} of photoelectrons emitted in a photoelectric cells is measured using lights of various frequencies υ. The graph in figure shows how K_{max} varies with υ. The slope of the graph is equal to



(a) the charge of an electron
(b) the charge and mass ratio of an electron
(c) the work function of the emitter in the cell
(d) Planck's constant.

19. The distance of the closest approach of an alpha particle fired at a nucleus with kinetic energy K is r_0. The distance of the closest approach when the alpha particle is fired at the same nucleus with kinetic energy $2K$ will be

(a) $2r_0$ (b) $4r_0$ (c) $\frac{r_0}{2}$ (d) $\frac{r_0}{4}$

20. The radius of a nucleus is

(a) proportional to its mass number
(b) inversely proportional to its mass number
(c) proportional to the cube root of its mass number
(d) not related to its mass number.

21. Which one of the following nuclear reactions is not possible ?

(a) ${}^{12}_{6}C + {}^{12}_{6}C \rightarrow {}^{20}_{10}Ne + {}^{4}_{2}He$
(b) ${}^{9}_{4}Be + {}^{1}_{1}H \rightarrow {}^{6}_{3}Li + {}^{4}_{2}He$
(c) ${}^{11}_{5}Be + {}^{1}_{1}H \rightarrow {}^{9}_{4}Be + {}^{4}_{2}He$
(d) ${}^{7}_{3}Li + {}^{4}_{2}He \rightarrow {}^{1}_{1}H + {}^{10}_{4}B$

22. In pure silicon at 300 K the electron and hole concentration is each equal to 1.5×10^{16} m^{-3}. When doped with indium, the hole concentration increases to 4.5×10^{22} m^{-3}. What is the electron concentration in doped silicon ?

(a) 3×10^9 m^{-3} (b) 4×10^9 m^{-3}
(c) 5×10^9 m^{-3} (d) 6×10^9 m^{-3}

23. A piece of copper and another of germanium are cooled from room temperature to 80 K. The resistance of

(a) each of them increases
(b) each of them decreases
(c) copper increases and that of germanium decreases
(d) copper decreases and that of germanium increases

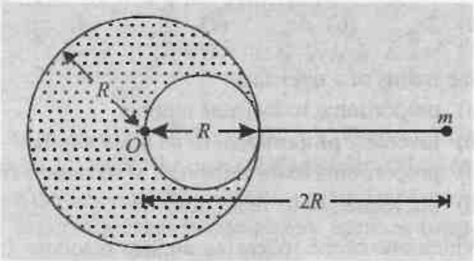
24. A full wave rectifier is fed with ac mains of frequency 50 Hz. What is the fundamental frequency of the

ripple in the output current ?
(a) 25 Hz (b) 50 Hz (c) 75 Hz (d) 100 Hz

25. In a transistor circuit, the collector current is 9.8 mA and the base current is 0.2 mA. The current gain β is
(a) 48 (b) 49 (c) 50 (d) 51

26. The electrical conductivity of a semiconductor increases when electromagnetic radiation of wavelength shorter than 2480 nm is incident on it. The band gap (in eV) for the semiconductor is
(a) 0.9 (b) 0.7 (c) 0.5 (d) 1.1

27. A uniform sphere of mass M and radius R exerts a force F on a small mass m situated at a distance of $2R$ from the centre O of the sphere. A spherical portion of diameter R is cut from the sphere as shown in figure. The force of attraction between the remaining part of the sphere and the mass m will be



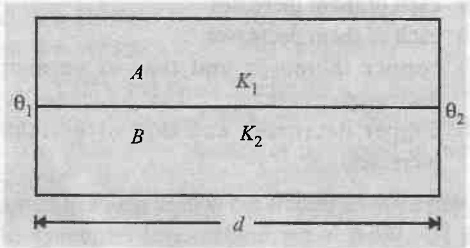
(a) $\frac{7F}{9}$ (b) $\frac{2F}{3}$ (c) $\frac{4F}{9}$ (d) $\frac{F}{3}$

28. A glass tube of radius r is dipped vertically into a container of mercury with its lower end at a depth h below the mercury surface. If σ is the surface tension of mercury, what must be the gauge pressure of air in the tube to blow a hemispherical bubble at the lower end ?

(a) $\frac{2\sigma}{r}+hg\rho$ (b) $\frac{2\sigma}{r}-hg\rho$

(c) $\frac{4\sigma}{r}+hg\rho$ (d) $\frac{4\sigma}{r}-hg\rho$

29. Two rods A and B of different materials are welded together as shown in figure. If their thermal conductivities are K_1 and K_2, the thermal conductivity of the composite rod will be



(a) $2(K_1+K_2)$ (b) $\frac{3}{2}(K_1+K_2)$

(c) (K_1+K_2) (d) $\frac{1}{2}(K_1+K_2)$

30. Two persons A and B, each carrying a source of sound of frequency υ, are standing a few metres apart in a quiet field. A starts moving towards B with a speed u. If v is the speed of sound, the number of beats heard per second by A will be

(a) $\frac{\upsilon u}{v}$ (b) $\frac{2\upsilon u}{v}$

(c) $\frac{\upsilon u}{(v+u)}$ (d) $\frac{\upsilon u}{(v-u)}$

31. In Young's double slit experiment, the 10[th] maximum of wavelength λ_1 is at a distance y_1 from its central maximum and the 5[th] maximum of wavelength λ_2 is at a distance y_2 from its central maximum. The ratio of y_1/y_2 will be

(a) $\frac{2\lambda_1}{\lambda_2}$ (b) $\frac{2\lambda_2}{\lambda_1}$ (c) $\frac{\lambda_1}{2\lambda_2}$ (d) $\frac{\lambda_2}{2\lambda_1}$

32. The maximum kinetic energies of photoelectrons emitted from a metal are K_1 and K_2 when it is irradiated with lights of wavelength λ_1 and λ_2 respectively. The work function of the metal is

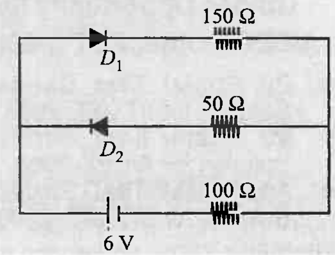
(a) $\frac{K_1\lambda_1-K_2\lambda_2}{\lambda_2-\lambda_1}$ (b) $\frac{K_1\lambda_1+K_2\lambda_2}{\lambda_2+\lambda_1}$

(c) $\frac{K_1\lambda_2-K_2\lambda_1}{\lambda_2-\lambda_1}$ (d) $\frac{K_1\lambda_2+K_2\lambda_1}{\lambda_2+\lambda_1}$

33. A 1 MeV positron and a 1 MeV electron meet each moving in opposite directions. They annihilate each other by emitting two photons. If the rest mass energy of an electron is 0.51 MeV, the wavelength of each photon is
(a) 5.1×10^{-3} Å (b) 10.2×10^{-3} Å
(c) 8.2×10^{-3} Å (d) 6.2×10^{-3} Å

34. The current gain (β) of a transistor in common emitter mode is 40. The change in collector current by 160 mA at constant V_{CE}, the necessary change in the base current is
(a) 0.25 μA (b) 4 μA
(c) 4 mA (d) 40 mA

35. The circuit shown in figure contains two diodes D_1 and D_2 each with a forward resistance of 50 ohms and with infinite backward resistance. If the battery voltage is 6 V, the current through the 100 ohm resistance (in amperes) is



(a) zero (b) 0.02 (c) 0.03 (d) 0.036

36. The binding energies per nucleon for ${}^2_1H$ and ${}^4_2He$ respectively are 1.1 MeV and 7.1 MeV. The energy released (in MeV) when two ${}^2_1H$ nuclei fuse to form ${}^4_2He$ is

(a) 4.4 (b) 8.2 (c) 24 (d) 28.4

37. Photoelectric emission is observed from a metallic surface for frequencies υ_1 nd υ_2 of the incident light ($\upsilon_1 > \upsilon_2$). If the maximum values of kinetic energy of the photoelectrons emitted in the two cases are in the ratio 1 : n, then the threshold frequency of the metallic surface is

(a) $\dfrac{\upsilon_1 - \upsilon_2}{n-1}$ (b) $\dfrac{n\upsilon_1 - \upsilon_2}{n-1}$

(c) $\dfrac{n\upsilon_2 - \upsilon_1}{n-1}$ (d) $\dfrac{\upsilon_1 - \upsilon_2}{n}$

38. When a plane electromagnetic wave travels in vacuum, the average electric energy density is given by (here E_0 is the amplitude of the electric field of the wave)

(a) $\frac{1}{4}\varepsilon_0 E_0^2$ (b) $\frac{1}{2}\varepsilon_0 E_0^2$ (c) $2\varepsilon_0 E_0^2$ (d) $4\varepsilon_0 E_0^2$

39. The period of oscillation of a simple pendulum of length L suspended from the roof of a vehicle which moves without friction down an inclined plane of inclination α, is given by

(a) $2\pi\sqrt{\dfrac{L}{g\cos\alpha}}$ (b) $2\pi\sqrt{\dfrac{L}{g\sin\alpha}}$

(c) $2\pi\sqrt{\dfrac{L}{g}}$ (d) $2\pi\sqrt{\dfrac{L}{g\tan\alpha}}$

40. A slab of stone of area 0.34 m^2 and thickness 10 cm is exposed on the lower face to steam at 100°C. A block of ice at 0°C rests on the upper face of the slab. In one hour, 3.6 kg of ice is melted. Assume that the heat loss from the sides is negligible. The latent heat of fusion of ice is 3.4×10^4 J kg^{-1}. What is the thermal conductivity of the stone in units of J s^{-1}m^{-1}°C^{-1} ?

(a) 1.0 (b) 1.5 (c) 2.0 (d) 2.5

CHEMISTRY

41. 64 gm of an organic compound contains 24 gm of carbon, 8 gm of H_2 and the rest oxygen. The empirical formula of the compound is

(a) CH_2O (b) C_2H_4O (c) CH_4O (d) $C_2H_8O_2$

42. Two compounds have the structural formula $CH_3 - O - CH_2 - CH_3$ and $CH_3CH_2CH_2OH$ is an example of

(a) Metamerism (b) Functional isomerism
(c) Positional isomerism
(d) Chain isomerism

43. The order of decreasing stability of the carbanions

(1) $(CH_3)_3\overline{C}$ (2) $(CH_3)_2\overline{C}H$

(3) $CH_3\overline{C}H_2$ (4) $C_6H_5\overline{C}H_2$ is

(a) $1 > 2 > 3 > 4$ (b) $4 > 3 > 2 > 1$
(c) $4 > 1 > 2 > 3$ (d) $1 > 2 > 4 > 3$

44. Alkene $RCH = CH_2$ and B_2H_6 react readily with H_2O_2 and the product on oxidation in alkaline medium produces

(a) RCH_2CHO (b) RCH_2CH_2OH

(c) $R-\underset{\underset{O}{\|}}{C}-CH_3$ (d) $R-\underset{\underset{OH}{|}}{CH}-\underset{\underset{OH}{|}}{CH_2}$

45. The predominant product formed, when 3-methyl-2-pentene reacts with HOCl is

(a) $CH_3-CH_2-\overset{\overset{Cl}{|}}{\underset{\underset{CH_3}{|}}{C}}-\overset{\overset{OH}{|}}{CH}-CH_3$

(b) $CH_3-CH_2-\overset{\overset{Cl}{|}}{\underset{\underset{CH_3}{|}}{C}}-\overset{\overset{Cl}{|}}{CH}-CH_3$

(c) $CH_3-CH_2-\overset{\overset{OH}{|}}{\underset{\underset{CH_3}{|}}{C}}-\underset{\underset{Cl}{|}}{CH}-CH_3$

(d) $CH_3-\overset{\overset{CH_3}{|}}{\underset{\underset{CH_3}{|}}{C}}-\overset{\overset{OH}{|}}{CH}-CH_3$

46. Which of the following reaction is expected to give a hydrocarbon product readily in good yields.

(a) $RCOOK \xrightarrow[\text{Oxidation}]{\text{Electrolysis}}$ (b) $RCOOAg \xrightarrow{I_2}$

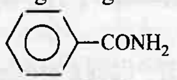
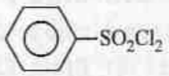
(c) $CH_3-CH_3 \xrightarrow[h\nu]{Cl_2}$ (d) $(CH_3)_2CHCl \xrightarrow{C_2H_5OH}$

47. $CH_2{=}CH_2 \xrightarrow[KOH/H_2O]{KMnO_4} X$, product X in the above reaction is
(a) ethylene glycol (b) glucose
(c) ethanol (d) all of the above

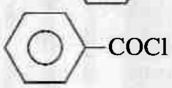
48. Reaction of phenol with dil HNO_3 gives
(a) p and m-nitrophenol (b) o and p-nitrophenol
(c) Picric acid (d) o and m-nitrophenol

49. The ester among the following is
(a) calcium lactate (b) ammonium acetate
(c) sodium acetate (d) none of these

50. Hinsberg's reagent is

(a)  (b) 

(c) 

(d) 

51. When methyl iodide is heated with ammonia the product obtained is
(a) methylamine (b) dimethylamine
(c) trimethyl amine
(d) mixture of all the three amines given in choices

52. Which of the following halides is least stable and has doubtful existence ?
(a) CI_4 (b) GeI_4 (c) SnI_4 (d) PbI_4

53. In the nitrogen family the H – M – H bond angle in the hydride MH_3 gradually becomes closer to 90° on going from N to Sb. This shows that gradually
(a) the basic strength of hydrides increases.
(b) almost pure p-orbitals are used for M – H bonding.
(c) the bond energies of M – H bond increases.
(d) the bond pairs of electrons become nearer to the control atom.

54. Which is used as hydrogen generators ?
(a) NaH (b) HI
(c) S_6H_3 (d) None of these

55. Solid PCl_5 exist as
(a) PCl_5 (b) PCl_4^+
(c) PCl_6^- (d) PCl_4^+ & PCl_6^-

56. The correct order and solubility in water for He, Ne, Ar, Kr Xe is
(a) He > Ne > Ar > Kr > Xe
(b) Ne > Ar > Kr > He > Xe
(c) Xe > Kr > Ar > Ne > He
(d) Ar > Ne > He > Kr > Xe

57. Which of the following statement is not true regarding transition elements?
(a) They readily form complex compound.
(b) They show variable valency.
(c) All their ions are colourless.
(d) Their ions contain partially filled d electron.

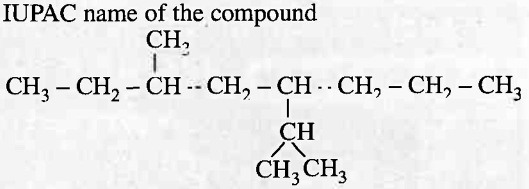
58. Acidified solution of chromic acid on treatment with hydrogen peroxide yields
(a) $CrO_3 + H_2O + O_2$ (b) $Cr_2O_3 + H_2O + O_2$
(c) $CrO_5 + H_2O$ (d) $H_2Cr_2O_7 + H_2O + O_2$

59. Which of the following is not a transition metal ?
(a) Chromium (b) Titanium
(c) Lead (d) Tungsten

60. Which of the following is expected to form colourless complex ?
(a) Ni^{2+} (b) Cu^+ (c) Ti^{3+} (d) Fe^{3+}

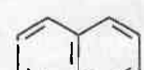
61. An organic compound has been found to possess the empirical formula CH_2O and molecular wt 90 . The molecular formula of it is
(a) $C_3H_6O_3$ (b) CH_2O (c) $C_2H_6O_2$ (d) C_2H_2O

62. IUPAC name of the compound



(a) 4- Isopropyl-1, 6-dimethyloctane
(b) 3-Methyl-5-(1′-methylethyl) octane
(c) 3-Methyl-5-isobutyloctane
(d) 6-Methyl-4-(1′-methylethyloctane)

63. Benzene reacts with CH_3COCl in the presence of $AlCl_3$ to give
(a) C_6H_5Cl (b) C_6H_5COCl
(c) $C_6H_5CH_3$ (d) $C_6H_5COCH_3$

64. The compound most likely to decolourise a solution of $KMnO_4$ is
(a) CH_3CH_3 (b) 
(c) $CH_3CH = CHCH_2CH_3$
(d) $(CH_3)_4C$

65. Acquired immuno deficiency syndrome (AIDS) is characterised as
(a) killer T-cells

(b) Reduction in number of T-cells
(c) An auto immune disease
(d) Inability of body to produce interferons

66. Which of the following is a correct statement ?
(a) Troleins are amino acid
(b) α-Hydrogen is present in fructose
(c) Starch is a polymer of α-glucose
(d) Amylose is compound of cellulose

67. Dacron is obtained by the condensation polymerisation of
(a) dimethyl terephthalate and ethylene glycol
(b) terephthalic acid and formaldehyde
(c) phenol and phthalic acid
(d) phenol and formaldehyde

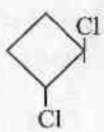
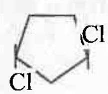
68. Nitrobenzene gives N-phenyl hydroxyl amine by
(a) Sn/HCl (b) $H_2/Pd - C$
(c) Zn/NaOH (d) Zn/NH_4Cl

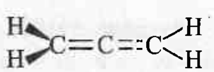
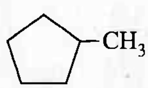
69. Which of the following set of elements doesn't belong to transition elements set
(a) Fe, Co, Ni (b) Cu, Au, Ag
(c) Ti, Zr, Hf (d) Ga, In, Tl

70. Which of the following will show increase in wt. when kept in magnetic field ?
(a) TiO_2 (b) $Fe_2(SO_4)_3$
(c) $KMnO_4$ (d) $ScCl_3$

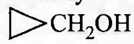
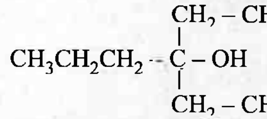
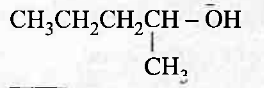
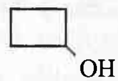
71. The proton on the phenol must be removed to start the reaction. Why is the phenolic proton acidic
(I) Electron withdrawing group are present
(II) The anion is stabilised by resonance
(III) The phenol is a carboxylic acid
(a) I only (b) II only
(c) I & II only (d) I & III only

72. Which of the following compound is optically inactive ?

(a)  (b) 

(c)  (d) 

73. The correct increasing order of extent of hydrolysis in the following compounds is
(a) $CCl_4 < MgCl_2 < AlCl_3 < SiCl_4 < PCl_5$
(b) $CCl_4 < AlCl_3 < MgCl_2 < PCl_5 < SiCl_4$
(c) $AlCl_3 < MgCl_2 < CCl_4 < PCl_5 < SiCl_4$
(d) $SiCl_4 < MgCl_2 < AlCl_3 < PCl_5 < CCl_4$

74. Which of the following turns solution cloudy immediately ?
(a) 
(b) 
(c) 
(d) 

75. $Z - CH = CH_2 \xrightarrow{HBr} Z = CH_2 - CH_2 - Br$ which of the following substituent might be best suited for Z ?
(a) –Cl (b) $-SO_3H$
(c) $-OCH_3$ (d) CH_3

76. Rate of reaction is generally influenced by change in solvent and its polarity. Which of the following combination (S_N2 reaction, reactant-effect on rate) is correct, when solvent polarity is increased ?
L = leaving group Nu^- = nucleophile
(a) R - L + Nu^- small decrease in rate
(b) R - L + Nu^- Large decrease in rate
(c) R - L^+ + Nu^- small decrease in rate
(d) None of these

77. Aq. solution of A on treatment with HCl,H_2S gives black precipitate. Thus which of the following cationic species must not be in the compound A ?
(a) Hg^+ (b) Pb^{2+} (c) Bi^{3+} (d) Cd^{2+}

78. The correct nucleophilicity order in DNF
(a) $CH_3^- > OH^- > NH_2^- > F^- > I^-$
(b) $CH_3 > OH^- > NH_2^- > I^- > F^-$
(c) $I^- > F^- > OH^- > NH_2^- > CH_3^-$
(d) $CH_3^- > NH_2^- > OH^- > F^- > I^-$

79. The dissolution of $Al(OH)_3$ by a solution of NaOH results in the formation of
(a) $[Al(H_2O)_4(OH)_2]^+$ (b) $[Al(H_2O)_3(OH)_3]$
(c) $[Al(H_2O)_2(OH)_4]^-$ (d) $[Al(H_2O)_6(OH)_3]$

80. The observed relative reactivities of alcohol towards reaction with a hydrogen halide are 3° > 2° > 1°. If secondary alcohols underwent an S_N2 reaction with a hydrogen halide rather then S_N1 reaction. The relative reactivities of the three classes of alcohol would be
(a) same (b) 2° > 3° > 1°
(c) 2° > 1° > 3° (d) 3° > 1° > 2°

81. $\int \frac{dx}{x^{1/5}(1+x^{4/5})^{1/2}}$ equals

(a) $\sqrt{1+x^{4/5}}+c$ (b) $x^{\frac{4}{5}}(1+x^{4/5})^{1/2}+c$

(c) $\frac{5}{2}\sqrt{1+x^{4/5}}+c$ (d) none of these

82. If $\int \frac{1}{x\sqrt{1-x^3}}dx = A\log\left|\frac{\sqrt{1-x^2}-1}{\sqrt{1-x^2}+1}\right| + B$, then A equals

(a) $-\frac{2}{3}$ (b) $-\frac{1}{3}$ (c) $\frac{1}{3}$ (d) $\frac{2}{3}$

83. When $n \in N$, the value of $\int_0^n [x]dx$, where $[x]$ is the greatest integer function, is

(a) $n(n-1)$ (b) $\frac{n(n-1)}{2}$

(c) $\frac{n(n+1)}{2}$ (d) none of these

84. $a_n = \int_1^{e^n} \frac{\pi \sin(\pi \log_e x)}{x} dx$ equals

(a) -2 (b) 2 (c) 2π (d) $\frac{2}{\pi}$

85. Area enclosed by $y = 1$ and $\pm 2x + y = 2$ (in square units) is

(a) $\frac{1}{2}$ (b) $\frac{1}{4}$ (c) 1 (d) 2

86. Area enclosed between the curve $y = x^{1/3}$, the y-axis and the line $y = -1$, $y = 1$ is

(a) 0 (b) $\frac{1}{2}$

(c) $\frac{3}{2}$ (d) none of these

87. The integrating factor of the differential equation $\frac{dy}{dx}(x\log x) + y = 2\log x$ is

(a) e^x (b) $\log x$

(c) $\log(\log x)$ (d) x

88. Family $y = Ax + A^3$ of curves is represented by the differential equation of degree

(a) three (b) two

(c) one (d) none of these

89. The co-ordinates of a point on the line $x + y = 3$ such that the point is at equal distances from the lines $|x| = |y|$ are

(a) (0, 3) (b) (0, 0) (c) (–3, 0) (d) (0, –3)

90. If a, b, c are in A.P., a, x, b are in G.P., and b, y, c are in G.P., then (x, y) lies on

(a) a st. line (b) a circle

(c) a parabola (d) an ellipse.

91. The equation of the circle whose radius is 5 and which touches the circle $x^2 + y^2 - 2x - 4y - 20 = 0$ at the point (5, 5) is

(a) $x^2 + y^2 + 18x + 16y + 120 = 0$

(b) $x^2 + y^2 - 18x - 16y + 120 = 0$

(c) $x^2 + y^2 - 18x + 16y + 120 = 0$

(d) $x^2 + y^2 + 18x - 16y + 120 = 0$

92. The circle $x^2 + y^2 - 6x - 10y + k = 0$ does not touch or intersect the x-axis and the point (1, 4) lies inside the circle, then

(a) $25 < k < 29$ (b) $9 < k < 25$

(c) $9 < k < 29$ (d) none of these

93. The length of the latus-rectum of the parabola $169\{(x-1)^2 + (y-3)^2\} = (5x - 12y + 17)^2$ is

(a) $\frac{12}{13}$ (b) $\frac{14}{13}$ (c) $\frac{28}{13}$ (d) $\frac{25}{13}$

94. Consider the equation of the parabola $y^2 + 4ax = 0$, where $a > 0$. Which of the following is false ?

(a) Vertex of the parabola is at the origin

(b) Focus of the parabola is $(a, 0)$

(c) Directrix of the parabola is $x = a$

(d) Tangent at the vertex is $x = 0$

95. The eccentricity of the ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$, whose latus-rectum is half its minor-axis is

(a) $\sqrt{\frac{2}{3}}$ (b) $\frac{1}{\sqrt{2}}$

(c) $\frac{\sqrt{3}}{2}$ (d) none of these

96. The foci of an ellipse are (0, ±1) and minor axis is of unit length. Then the equation of the ellipse is

(a) $2x^2 + y^2 = 2$ (b) $x^2 + 2y^2 = 2$

(c) $4x^2 + 20y^2 = 5$ (d) $20x^2 + 4y^2 = 5$

97. The equations $x = \frac{e^t + e^{-t}}{2}, y = \frac{e^t - e^{-t}}{2}, t \in R$ represent

(a) a circle (b) a parabola
(c) an ellipse (d) a hyperbola

98. 12 persons are to be arranged to a round table. If two particular persons among them are not to be side by side, the total number of arrangements is
(a) 9(10!) (b) 2(10!) (c) 45(10!) (d) 10!

99. All the letters of the word 'EAMCET' are arranged in all possible ways. The number of such arrangements in which two vowels are adjacent to each other is
(a) 360 (b) 144 (c) 72 (d) 54

100. Two persons throw a pair of dice alternatively till one gets a total of 9 and wins the game. If A has the first throw, then the probability that A wins the game is
(a) $\frac{9}{17}$ (b) $\frac{8}{17}$
(c) 1/2 (d) none of these

101. If mean of a binomial distribution is 3 and its variance is $\frac{3}{2}$, then number of trials is
(a) 6 (b) 2
(c) 12 (d) none of these

102. The minimum value of $\sin\theta \cos\theta$ is
(a) 1 (b) 0 (c) $-\frac{1}{2}$ (d) $\frac{1}{2}$

103. In a triangle ABC,
$\operatorname{cosec}A (\sin B \cos C + \cos B \sin C)$ is
(a) c/a (b) a/c
(c) 1 (d) none of these

104. If in a
ΔABC $4\cos A \cos B + \sin 2A + \sin 2B + \sin 2C = 4$
then the triangle is
(a) equilateral (b) only right angled
(c) isosceles and right angled
(d) none of these

105. In a triangle ABC, $(a + b + c)(b + c - a) = \lambda bc$ if
(a) $0 < \lambda < 4$ (b) $\lambda > 4$
(c) $\lambda < 0$ (d) $\lambda > 0$

106. In a ΔABC, if $Rr (\sin A + \sin B + \sin C) = 96$, then the area of the triangle in square units, equals
(a) 24 (b) 48 (c) 72 (d) 96

107. The perimeter of a triangle, right-angled at C, is 70, and the inradius is 6, $|a - b|$ equals
(a) 1 (b) 3 (c) 7 (d) 9

108. If $\frac{1}{6}\sin\theta$, $\cos\theta$ and $\tan\theta$ are in G.P., then the general value of θ is:
(a) $2n\pi \pm \frac{\pi}{3}$ $n \in Z$ (b) $2n\pi \pm \frac{\pi}{6}$, $n \in Z$
(c) $n\pi + (-1)^n \frac{\pi}{3}$, $n \in Z$ (d) $n\pi + \frac{\pi}{3}$, $n \in Z$

109. At a point A, the angle of elevation of a tower is such that tangent is $\frac{5}{12}$, on walking 240 m nearer the tower, the tangent of the angle of elevation is $\frac{3}{4}$. Then the height (in m) of the tower is
(a) 220 (b) 225
(c) 224 (d) none of these

110. If $x = \sin^{-1}k$, $y = \cos^{-1}k$, $-1 < k < 1$, then the correct relationship is
(a) $x + y = 2$ (b) $x - y = 2$
(c) $x + y = \frac{\pi}{2}$ (d) $x - y = \frac{\pi}{2}$

111. Two forces act at an angle of 120°. The greater force is represented by 80 kg and the resultant is at rt. angles to the lesser. The lesser force is
(a) 60 kg (b) 40 kg
(c) 50 kg (d) None of these

112. The resultant of two forces, each equal to P in magnitude acting at an angle α is of magnitude R and the resultant of $\bar{P}$ and $\frac{1}{3}\bar{R}$ acting at $rt.$ angles is of magnitude $\frac{2}{3}R$. The value of α is
(a) $\pi/2$ (b) $\pi/6$
(c) $\pi/3$ (d) none of these

113. A particle moves in a st. line and its law of motion is given by $s^2 = 3t^2 + 2t + 4$. Show that the acceleration varies as
(a) $\frac{1}{s^3}$ (b) $\frac{1}{s^2}$ (c) $\frac{1}{s}$ (d) $\frac{1}{s^4}$

114. Displacement in time t is
(a) $s = \frac{1}{2}(u + v)$ (b) $s = \frac{1}{2}t(u + v)$
(c) $s = \frac{1}{2}tu$ (d) $s = \frac{1}{2}tv$

115. The mean wage of 1000 workers in a factory running in two shifts of 700 and 300 workers is Rs. 500. The mean wage of 700 workers working in day shift is Rs. 450. The mean wage of workers working in the night shift is
(a) Rs. 570 (b) Rs. 616.67
(c) Rs. 543.67 (d) none of these

116. If each observation of a raw data whose variance is σ^2, is increased by λ, then the variance of the new set is
(a) $\sigma^2 + \lambda$ (b) $\sigma^2 + \lambda^2$
(c) $\sigma^2\lambda^2$ (d) none of these

117. If S.D. of n observation $x_1, x_2, ..., x_n$ is 7 and another set of n observations $y_1, y_2, ..., y_n$ is 8, then S.D. of n observations $x_1 - y_1, x_2 - y_2, ..., x_n - y_n$ is
(a) 1 (b) $\sqrt{\frac{7}{8}}$
(c) –1 (d) none of these

118. If G is the G.M. of the product of K sets of observations, with GM's $G_1, G_2 ....G_K$ respectively, then G is equal to
(a) $\log G_1 + \log G_2 + ...+ \log G_K$
(b) $\log G_1 \log G_2 ..... \log G_K$
(c) $G_1 G_2 ..... G_K$
(d) none of these.

119. The relationship between mean, median and mode for a moderately skewed distribution is
(a) Mode = Median – 2 Mean
(b) Mode = 2 Median – Mean
(c) Mode = 3 Median – 2 Mean
(d) Mode = 2 Median – 3 Mean

120. Variance is independent of
(a) origin only
(b) scale only
(c) origin and change of scale
(d) none of these.

ANSWERS

1.	(b)	**2.**	(a)	**3.**	(c)	**4.**	(a)	**5.**	(b)
6.	(a)	**7.**	(c)	**8.**	(d)	**9.**	(c)	**10.**	(b)
11.	(a)	**12.**	(b)	**13.**	(d)	**14.**	(c)	**15.**	(c)
16.	(d)	**17.**	(d)	**18.**	(d)	**19.**	(c)	**20.**	(c)
21.	(c)	**22.**	(c)	**23.**	(d)	**24.**	(d)	**25.**	(b)
26.	(c)	**27.**	(a)	**28.**	(a)	**29.**	(d)	**30.**	(a)
31.	(a)	**32.**	(a)	**33.**	(c)	**34.**	(c)	**35.**	(b)
36.	(c)	**37.**	(b)	**38.**	(a)	**39.**	(a)	**40.**	(a)
41.	(c)	**42.**	(b)	**43.**	(b)	**44.**	(b)	**45.**	(c)
46.	(a)	**47.**	(a)	**48.**	(b)	**49.**	(d)	**50.**	(b)
51.	(d)	**52.**	(d)	**53.**	(d)	**54.**	(a)	**55.**	(d)
56.	(c)	**57.**	(c)	**58.**	(c)	**59.**	(c)	**60.**	(b)
61.	(a)	**62.**	(b)	**63.**	(d)	**64.**	(c)	**65.**	(b)
66.	(c)	**67.**	(a)	**68.**	(d)	**69.**	(d)	**70.**	(b)
71.	(c)	**72.**	(c)	**73.**	(a)	**74.**	(b)	**75.**	(b)
76.	(a)	**77.**	(d)	**78.**	(d)	**79.**	(c)	**80.**	(d)
81.	(c)	**82.**	(c)	**83.**	(b)	**84.**	(b)	**85.**	(a)
86.	(b)	**87.**	(b)	**88.**	(a)	**89.**	(a)	**90.**	(b)
91.	(b)	**92.**	(c)	**93.**	(c)	**94.**	(b)	**95.**	(c)
96.	(d)	**97.**	(d)	**98.**	(a)	**99.**	(c)	**100.**	(a)
101.	(a)	**102.**	(c)	**103.**	(c)	**104.**	(c)	**105.**	(a)
106.	(d)	**107.**	(a)	**108.**	(a)	**109.**	(b)	**110.**	(c)
111.	(b)	**112.**	(c)	**113.**	(b)	**114.**	(b)	**115.**	(b)
116.	(d)	**117.**	(d)	**118.**	(c)	**119.**	(c)	**120.**	(a)

Forthcoming Competitive Exams

CBSE PMT Preliminary Exam	April 6
IIT-JEE	April 13
West Bengal JEE	April 20
MGIMS	April 20
CBSE AIEEE	April 27
AFMC	May 4
BHU PMT Screening	May 7
BITSAT	May 9 to 12 June
CBSE PMT Mains Exam.	May 11
DPMT	May 18
DCE	May 31
BHU PMT Mains	June 15

AIIMS | CBSE | DPMT | AFMC | VMMC | EAMCET | WB-JEE | BHU | CMC | UPCPMT | Manipal PMT

According to new pattern

Practice Paper for Medical Entrance Exam 2008

MP-PMT | MGIMS | PMDT Bihar | PMT Haryana | Kerala PMT | Raj. PMT | TNPCEE | JIPMER | CET Karnataka

1. A 20 kg block is initially at rest on a rough horizontal surface. A horizontal force of 75 N is required to set the block in motion. After it is in motion, a horizontal force of 60 N is required to keep the block moving with constant speed. The coefficient of static friction is
(a) 0.38 (b) 0.44
(c) 0.52 (d) 0.60

2. The total kinetic energy of a rolling sphere having translational velocity v is
(a) $\frac{7}{10}Mv^2$ (b) $\frac{1}{2}Mv^2$
(c) $\frac{2}{5}Mv^2$ (d) $\frac{10}{7}Mv^2$

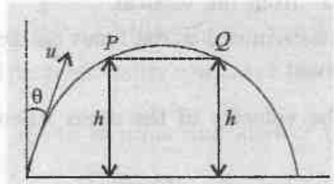
3. A car accelerates from rest at a constant rate α for some time, after which it deaccelerates at a constant rate β and comes to rest. If the total time elapsed is t, then the maximum velocity acquired by the car is
(a) $\left(\frac{\alpha^2+\beta^2}{\alpha\beta}\right)t$ (b) $\left(\frac{\alpha^2-\beta^2}{\alpha\beta}\right)t$
(c) $\frac{(\alpha+\beta)t}{\alpha\beta}$ (d) $\frac{\alpha\beta t}{\alpha+\beta}$

4. Which of the following pair does not have similar dimensions?
(a) Stress and pressure (b) Angle and strain
(c) Tension and surface tension
(d) Planck's constant and angular momentum

5. The speed of a boat is 5 km/h in still water. It crosses a river of width 1.0 km along the shortest possible path in 15 minutes. The velocity of the river water is (in km/h)
(a) 5 (b) 1
(c) 3 (d) 4

6. If 2 kg mass is rotating on a circular path of radius 0.8 m with angular velocity of 44 rad/sec. If radius of the path becomes 1 m. then what will be the value of angular velocity?
(a) 28.16 rad/sec (b) 19.28 rad/sec
(c) 8.12 rad/sec (d) 35.26 rad/sec

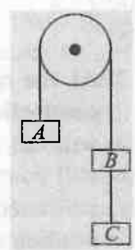
7. A particle is thrown with velocity u making an angle θ with the vertical. It just crosses the top of two poles each of height h after 1 s and 3 s respectively. The maximum height of projectile is



(a) 9.8 m (b) 19.6 m
(c) 39.2 m (d) 4.9 m

8. A man slides down a light rope whose breaking strength is η times his weight. What should be his maximum acceleration so that the rope just not breaks?
(a) $g(1-\eta)$ (b) ηg
(c) $\frac{g}{1+\eta}$ (d) $\frac{g}{1-\eta}$

9. Three equal weights A, B, C of mass 2 kg each are hanging on a string passing over a fixed frictionless pulley as shown in figure. The tension in the string connecting weights B and C is



(a) zero
(b) 13.0 newton
(c) 3.3 newton (d) 19.6 newton

10. A cricketer catches a ball of mass 150 g in 0.1 sec moving with speed 20 m/s, then he experiences force of
(a) 300 N (b) 30 N
(c) 3 N (d) 0.3 N

11. Two equal masses m_1 and m_2 moving along same straight line with velocities + 3 m/s and − 5 m/s respectively collide elastically. Their velocities after collision will be respectively
(a) + 4 m/s for both (b) − 3 m/s and + 5 m/s
(c) − 4 m/s and + 4 m/s (d) − 5 m/s and + 3 m/s

12. A body of mass M is hung by a long thread and a bullet of mass m hits it horizontally with a velocity v and gets embedded in the body. Then for the body and the bullet system

(a) momentum $- \left(\dfrac{M\,m}{M+m}\right)v$

(b) kinetic energy $= \dfrac{1}{2}\,m\,v^2$

(c) momentum $= \dfrac{(M+m)\,m\,v}{M}$

(d) kinetic energy $= \dfrac{m^2\,v^2}{2\,(M+m)}$

13. Moment of inertia of a uniform rod of length L and mass M, about an axis passing through $L/4$ from one end and perpendicular to its length is

(a) $\dfrac{7}{36}ML^2$ (b) $\dfrac{7}{48}ML^2$ (c) $\dfrac{11}{48}ML^2$ (d) $\dfrac{ML^2}{12}$

14. Two particles having mass M and m are moving in a circular path having radius R and r. If their time periods are same, then the ratio of angular velocity will be

(a) $\dfrac{r}{R}$ (b) $\dfrac{R}{r}$ (c) 1 (d) $\sqrt{\dfrac{R}{r}}$

15. A wheel having moment of inertia 2 kg m^2 about its vertical axis, rotates at the rate of 60 rpm about this axis. The torque which can stop the wheel's rotation in one minute would be

(a) $\dfrac{\pi}{15}$ Nm (b) $\dfrac{\pi}{18}$ Nm (c) $\dfrac{2\pi}{15}$ Nm (d) $\dfrac{\pi}{12}$ Nm

16. If g is the acceleration due to gravity on earth then increase in potential energy of a body of mass m upto a distance equal to twice the radius of the earth from the earth surface is

(a) $\dfrac{1}{2}mgR$ (b) $\dfrac{2}{3}mgR$

(c) $2\,mgR$ (d) $\dfrac{1}{4}mgR$

17. A cylindrical vessel is filled with water up to height H. A hole is bored in the wall at a depth h from the free surface of water. For maximum range, h is equal to

(a) $H/4$ (b) $H/2$ (c) $3H/4$ (d) H.

18. If S is stress and Y is Young's modulus of material of a wire, then the energy stored in the wire per unit volume is

(a) $\dfrac{S^2}{2Y}$ (b) $\dfrac{2Y}{S^2}$ (c) $\dfrac{S}{2Y}$ (d) $2S^2Y$

19. A cube is subjected to a uniform volume compression. If the side of the cube decreases by 1%, the bulk strain is

(a) 0.01 (b) 0.02 (c) 0.03 (d) 0.06

20. If the surface tension of water is 0.06 Nm^{-1}, then the capillary rise in a tube of a diameter 1 mm is ($\cos 0 = 0°$)

(a) 1.22 cm (b) 2.44 cm

(c) 3.12 cm (d) 3.86 cm

21. If the r.m.s. speed of a gas molecule at 27°C is $100\sqrt{2}$ ms^{-1}. The r.m.s. speed at 327°C would be

(a) 100 ms^{-1} (b) 200 ms^{-1}

(c) 300 ms^{-1} (d) 400 ms^{-1}.

22. Surface tension of water is 0.072 Nm^{-1}. The excess pressure inside a water drop of diameter 1.2 mm is

(a) 240 Nm^{-2} (b) 120 Nm^{-2}

(c) 0.06 Nm^{-2} (d) 72 Nm^{-2}

23. If λ_m denotes the wavelength at which the radiative emission from a black body at a temperature T K is maximum, then

(a) $\lambda_m \propto T$ (b) $\lambda_m \propto T^{-1}$

(c) $\lambda_m \propto T^{-4}$

(d) λ_m does not depend on T

24. The temperatures T_1 and T_2 of heat reservoirs in the ideal Carnot engine are 1500°C and 500°C respectively. If T_1 increases by 100°C, what will be the efficiency of the engine?

(a) 62% (b) 59% (c) 65% (d) 100%

25. During an adiabatic process, the pressure of a gas is found to be proportional to the cube of its absolute temperature. The ratio C_P/C_V for gas is

(a) 4/3 (b) 2 (c) 5/3 (d) 3/2

26. A particle is performing simple harmonic motion along x-axis with amplitude 4 cm and time period 1.2 sec. The minimum time taken by the particle to move from $x = +2$ to $x = +4$ cm and back again is given by

(a) 0.4 s (b) 0.3 s (c) 0.2 s (d) 0.6 s

27. Velocity of a body moving in simple harmonic motion, is

(a) $\omega^2\sqrt{a^2+y^2}$ (b) $\omega\sqrt{a^2-y^2}$

(c) $\omega\sqrt{a^2+y^2}$ (d) $\omega^2\sqrt{a^2-y^2}$.

28. Two infinite plane parallel sheets, separated by a distance d have equal and opposite uniform charge densities σ. Electric field at a point between the sheets is

(a) depends upon location of the point

(b) $\frac{\sigma}{2\varepsilon_0}$ (c) $\frac{\sigma}{\varepsilon_0}$

(d) zero

29. A charge Q μC is placed at the centre of a cube, the flux coming out from any face will be

(a) $\frac{Q}{6\varepsilon_0}\times 10^{-6}$ (b) $\frac{Q}{6\varepsilon_0}\times 10^{-3}$

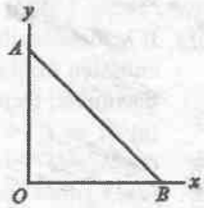
(c) $\frac{Q}{24\varepsilon_0}$ (d) $\frac{Q}{8\varepsilon_0}$

30. Elecric field at the centroid of a triangle carrying q charge at each corner is

(a) zero (b) $\frac{\sqrt{2}\,Kq}{r^2}$

(c) $\frac{1}{\sqrt{2}}\frac{Kq}{r^2}$ (d) $\frac{3Kq}{r^2}$

31. As per a point charge $+q$ is placed at the origin O. Work done in taking another point charge $-Q$ from the point A [coordinates $(0, a)$] to another point B [coordinates $(a, 0)$] along the straight path AB is



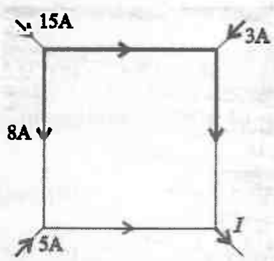
(a) $\left(\frac{-qQ}{4\pi\varepsilon_0}\frac{1}{a^2}\right)\sqrt{2}\,a$ (b) zero

(c) $\left(\frac{qQ}{4\pi\varepsilon_0}\cdot\frac{1}{a^2}\cdot\frac{a}{\sqrt{2}}\right)$ (d) $\left(\frac{qQ}{4\pi\varepsilon_0}\frac{1}{a^2}\right).\sqrt{2}\,a$

32. Two wires of same metal have the same length but their cross sections are in the ratio 3 : 1. They are joined in series. The resistance of the thicker wire is 10 Ω. The total resistance of the combination is

(a) (5/2) Ω (b) (40/3)Ω (c) 40 Ω (c) 100 Ω

33. The figure shows a network of currents. The magnitude of current is shown here. The current I will be



(a) – 3 (b) 3 A (c) 13 A (d) 23 A

34. Two resistors whose value are in ratio 2 : 1 are connected in parallel with one cell. Then ratio of power dissipated is

(a) 2 : 1 (b) 4 : 1 (c) 1 : 2 (d) 1 : 1

35. The maximum power drawn out of the cell from a source is given by (E = emf of a cell, r = internal resistance of a cell)

(a) $E^2/2r$ (b) $E^2/4r$ (c) E^2/r (d) $E^2/3r$

36. The magnetic field due to a current carrying circular loop of radius 3 cm at a point on the axis at a distance of 4 cm from the centre is 54 μT. What will be its value at the centre of the loop?

(a) 250 μT (b) 150 μT (c) 125 μT (d) 75 μT.

37. A charged particle moving with velocity 2×10^3 m/s passes undeflected through electric and magnetic fields. Magnetic field is 1.5 tesla. The electric field intensity is

(a) 2×10^3 N/C (b) 1.5×10^3 N/C

(c) 3×10^3 N/C (d) $4/3\times 10^{-3}$ N/C

38. To produce a magnetic field of π tesla at the centre of circular loop of diameter 1 m, the current flowing through loop is

(a) 5×10^6 A (b) 10^7 A

(c) 2.5×10^6 A (d) 2×10^6 A

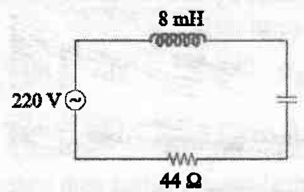
39. The magnetic moment of a current I carrying circular coil of radius r and number of turns N varies as

(a) $1/r^2$ (b) $1/r$ (c) r (d) r^2

40. The current flowing in a coil of self inductance 0.4 mH is increased by 250 mA in 0.1 s. The e.m.f. induced will be

(a) + 1 V (b) – 1 V (c) + 1 mV (d) –1 mV

41. For the series LCR circuit shown in figure, what is the resonance frequency and the amplitude of the current at the resonating frequency?



(a) 2500 rads^{-1} and $5\sqrt{2}$ A

(b) 2500 rads^{-1} and 5 A

(c) 2500 rads^{-1} and $\frac{5}{\sqrt{2}}$ A

(d) 250 rads^{-1} and $5\sqrt{2}$ A

42. Soap bubble looks coloured due to

(a) dispersion (b) reflection

(c) interference (d) none of these

3. Two waves of same frequency, but of amplitudes in the ratio 1 : 3 are superimposed. The ratio of maximum to minimum intensity is
(a) 4 : 1 (b) 1 : 4 (c) 3 : 1 (d) 1 : 3

4. The radius of curvature of a thin planoconvex lens is 10 cm (of curved surface) and the refractive index is 1.5. It the plane surface is silvered, then the focal length will be
(a) 15 cm (b) 20 cm (c) 5 cm (d) 10 cm

5. If convex lens of focal length 80 cm and a concave lens of focal length 50 cm are combined together, what will be their resulting power?
(a) + 6.5 D (b) – 6.5 D
(c) – 0.75 D (d) + 7.5 D

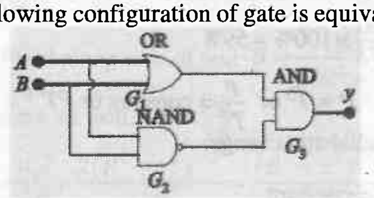
6. An electron of charge e is liberated from a hot filament and attracted by an anode of potential V volts positive with respect to the filament. The speed of the electron of mass m when it strikes the anode is
(a) eV^2 (b) meV
(c) $\sqrt{2e/mV}$ (d) $\sqrt{2eV/m}$

7. At any instant, the ratio of the amount of radioactive substances is 2 : 1. If their half lives be respectively 12 and 16 hours, then after two days, what will be the ratio of the substances?
(a) 1 : 1 (b) 2 : 1 (c) 1 : 2 (d) 1 : 4

8. Complete the equation for the following fission process
${}_{92}U^{235} + {}_0n^1 \rightarrow \ldots\ {}_{38}Kr^{90} + \ldots$
(a) ${}_4Xe^{143} + 3\ {}_0n^1$ (b) ${}_{54}Xe^{145}$
(c) ${}_{57}Xe^{142}$ (d) ${}_{54}Xe^{142} + {}_0n^1$

9. The part of a transistor which is heavily doped to produce a large number of majority carriers is
(a) base (b) emitter
(c) collector (d) none of these

0. The following configuration of gate is equivalent to



(a) NAND (b) XOR
(c) OR (d) none of these

SOLUTIONS

1. (a) : $F = \mu R = \mu Mg$
75 = $\mu \times 20 \times 9.8$ for static friction

$$\mu = \frac{75}{196} = 0.38$$

2. (a) : Kinetic energy of rolling sphere

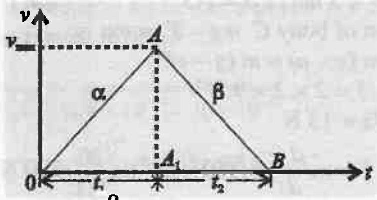
$$= \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2$$

For sphere, $I = \frac{2}{5}MR^2$ and $R\omega = v$

$$\therefore\ KE = \frac{1}{2}Mv^2 + \frac{1}{2}\left(\frac{2}{5}MR^2\right)\omega^2$$

$$= \frac{1}{2}Mv^2 + \frac{1}{5}Mv^2 = \frac{7}{10}Mv^2$$

3. (d) :



$AA_1 = v_{max.} = \alpha\, t_1 = \beta\, t_2$

But $t = t_1 + t_2 = \frac{v_{max}}{\alpha} + \frac{v_{max}}{\beta}$

$$= v_{max}\left(\frac{1}{\alpha} + \frac{1}{\beta}\right) = v_{max}\left(\frac{\alpha+\beta}{\alpha\beta}\right)$$

or $v_{max} = \left(\frac{\alpha\beta}{\alpha+\beta}\right)t$

4. (c) : Tension is force, and surface tension is force/length so they do not have the same dimensions.

5. (c) : The resultant velocity of boat and river = 1.0 km/0.25 h = 4 km/h.

Velocity of river = $\sqrt{5^2 - 4^2} = 3$ km/h

6. (a) : Mass (m) = 2 kg; initial radius of the path (r_1) = 0.8 m; initial angular velocity (ω_1) = 44 rad/sec and final radius of the path (r_2) = 1 m.
Moment of inertia, $I_1 = mr_1^2 = 2 \times (0.8)^2 = 1.28$ kg-m^2 and $I_2 = mr_2^2 = 2 \times (1)^2 = 2$ kg-m^2.
Therefore from the law of conservation of angular momentum $I_1\omega_1 = I_2\omega_2$ or $\omega_2 = \frac{I_1 \times \omega_1}{I_2} = \frac{1.28 \times 44}{2}$
$\omega_2 = 28.16$ rad/sec.

7. (b) : Using the relation, $s = ut + \frac{1}{2}at^2$, we have

$$h = u\cos\theta\, t_1 - \frac{1}{2}gt_1^2 = u\cos\theta\, t_2 - \frac{1}{2}gt_2^2$$

or $u\cos\theta \times 1 - \frac{1}{2} \times 9.8 \times 1^2$

$$= u\cos\theta \times 3 - \frac{1}{2} \times 9.8 \times 3^2$$

or $u\cos\theta\,(3 - 1) = 4.9 \times (9 - 1) = 4.9 \times 8$

$$u\cos\theta = \frac{4.9 \times 8}{2} = 4.9 \times 4 = 19.6 \text{ m/s}$$

Max. height $= \frac{u^2\cos^2\theta}{2g} = \frac{(19.6)^2}{2 \times 9.8} = 19.6$ m

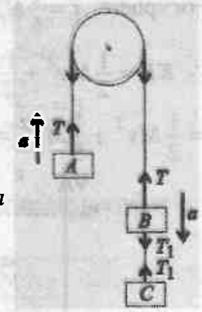
8. (a) : $mg - R = ma$
$mg - \eta\, mg = ma$
$mg\,(1 - \eta) = ma,\ a = g\,(1 - \eta)$

9. (b) : Let T be the tension in the string. Let the bodies B and C accelerate downwards with acceleration a. Then the body A moves upwards with acceleration a. Therefore, for motion of body A

$T - mg = ma$ ...(i)

For motion of body B and C

$2\,mg - T = 2\,m \times a$ ...(ii)



Adding (i) and (ii), we get

$2\,mg - mg = 3\,ma$ or $a = g/3$.

For motion of body C $mg - T_1 = ma$

or $T_1 = m\,(g - a) = m\,(g - g/3)$

$T_1 = 2\,mg/3 = 2 \times 2 \times 9.8/3$

$T_1 = 39.2/3 = 13$ N

10. (b) : $F = m\dfrac{dv}{dt} = (150 \times 10^{-3}) \times \dfrac{20}{0.1} = 30$ N

11. (d) : When $m_1 = m_2$, the velocities are just exchanged after perfectly elastic collision.

12. (d) : Velocity of system $= \dfrac{m\,v}{M + m}$

K.E. of system $= \dfrac{1}{2}(M + m)\left(\dfrac{m\,v}{M + m}\right)^2 = \dfrac{m^2\,v^2}{2\,(M + m)}$

13. (b) : Applying theorem of parallel axes,

$I = I_0 + M\,(L/4)^2 = \dfrac{ML^2}{12} + \dfrac{ML^2}{16} = \dfrac{7}{48}ML^2$

14. (c) : As $\omega = \dfrac{2\pi}{T}$ and T is same, therefore, ω must be same i.e. $\dfrac{\omega_1}{\omega_2} = 1$

15. (a) : Here, $I = 2$ kg m^2, $\upsilon_1 = 60$ r.p.m. $= 1$ r.p.s.

$\tau = ?$, $\upsilon_2 = 0$, $t = 1$ min $= 60$ s

$\tau = I\,\alpha = \dfrac{I\,(\omega_2 - \omega_1)}{t} = \dfrac{I\,2\pi\,(\upsilon_2 - \upsilon_1)}{t}$

$= \dfrac{2 \times 2\,\pi\,(0 - 1)}{60} = -\dfrac{\pi}{15}$ N.m.

16. (b) : Change in potential energy of body is

$\Delta U = -\dfrac{GM\,m}{(R + 2R)} - \left(-\dfrac{GM\,m}{R}\right)$

$= \dfrac{2GM\,m}{3R} = \dfrac{2}{3}\left(\dfrac{GM}{R^2}\right)m\,R = \dfrac{2}{3}mg\,R$

17. (b) : Horizontal velocity of water flowing out of hole

$u = \sqrt{2\,gh}$

Height of hole from ground level $= (H - h)$. The time taken by water to cover vertical distance $(H - h)$ can be calculated from

$(H - h) = \dfrac{1}{2}gt^2 \quad or\ t = \sqrt{2\,(H - h)/g}$

Horizontal range,

$R = ut = \sqrt{2\,gh} \times \sqrt{2\,(H - h)/g} \;=\; 2\sqrt{h\,(H - h)}$

Horizontal range will be maximum if $dR/dh = 0$.

i.e. $2 \times \dfrac{1}{2}(hH - h^2)^{-1/2} \times (H - 2h) = 0$

or $H = 2h$ or $h = H/2$

18. (a) : Energy stored per unit volume

$= \dfrac{1}{2} \times \text{stress} \times \text{strain} = \dfrac{1}{2} \times \text{stress} \times \dfrac{\text{stress}}{Y} = \dfrac{1}{2}\dfrac{S^2}{Y}$

19. (c) : Let L be the length of each side of cube. Initial volume $= L^3$. When each side decreases by 1%, new length $L' = L - \dfrac{L}{100} = \dfrac{99\,L}{100}$

New volume $= L'^3 = (99\,L/100)^3$

Change in volume, $\Delta V = L^3 - (99\,L/(100)^3$

or $\Delta V = L^3\left[1 - \left(1 - \dfrac{1}{100}\right)^3\right]$

$= L^3\left[1 - \left(1 - \dfrac{3}{100} + ...\right)\right] = L^3\left[\dfrac{3}{100}\right] = \dfrac{3L^3}{100}$

[neglecting higher order term]

$\therefore$ Bulk strain $= \dfrac{\Delta V}{V} = \dfrac{3L^3/.100}{L^3} = 0.03$

20. (b) : $h = 2\,S\cos\theta/\,r\,\rho\,g$

$= \dfrac{2 \times 0.06 \times \cos 0^\circ}{10^{-5} \times 0.5 \times 10^3 \times 9.8} = 2.44 \times 10^{-2}$ m $= 2.44$ cm

21. (b) : $v_{r.m.s.} \propto \sqrt{T}$

$\therefore \dfrac{(v_{r.m.s.})_1}{(v_{r.m.s})_2} = \sqrt{\dfrac{T_1}{T_2}} = \sqrt{\dfrac{(27 + 273)}{(327 + 273)}} = \sqrt{\dfrac{300}{600}} = \dfrac{1}{\sqrt{2}}$

or $(v_{r.m.s})_2 = (v_{r.m.s.})_1\sqrt{2} = (100\sqrt{2}) \times \sqrt{2} = 200$ ms^{-1}

22. (a) : $P = \dfrac{2S}{r} = \dfrac{4S}{D} = \dfrac{4 \times 0.072}{1.2 \times 10^{-3}} = 240$ Nm^{-2}

23. (b) : According to Wien's law $\lambda_m = \dfrac{b}{T}$

$\therefore \quad \lambda_m \propto \dfrac{1}{T}$

24. (b) : $T_1 = 1500 + 100 = 1600$°C

$= 1600 + 273$ K $= 1873$ K

$T_2 = 500$°C $= 500 + 273 = 773$ K

$\eta = 1 - \dfrac{T_2}{T_1} = 1 - \dfrac{773}{1873} = \dfrac{1100}{1873}$

$\eta = \dfrac{1100}{1873} \times 100\% = 59\%$

25. (d) : $P \propto T^3$ or $\dfrac{P}{T^3}$ = constant or PT^{-3} = constant

For an adiabatic change,

$PT^{\frac{\gamma}{1-\gamma}}$ = constant

$\therefore \quad \dfrac{\gamma}{1 - \gamma} = -3$ or $-3 + 3\,\gamma = \gamma$ or $2\,\gamma = 3$ or $\gamma = 3/2$

26. (a) : When particle is at $x = 2$, the displacement is $y = 4 - 2 = 2$ cm. If t is the time taken by the particle to go from $x = 4$ cm to $x = 2$ cm, then

$y = a\cos\omega t = a\cos\frac{2\pi t}{T} = a\cos\frac{2\pi t}{1.2}$

or $\cos\frac{2\pi t}{1.2} = \frac{y}{a} = \frac{2}{4} = \frac{1}{2} = \cos\frac{\pi}{3}$

or $\frac{2t}{1.2} = \frac{1}{3}$ or $t = \frac{1.2}{6} = 0.2$ s

Time taken to move from $x = +2$ cm to $x = +4$ cm and back again $= 2t = 2 \times 0.2$ s $= 0.4$ s

27. (b) : Displacement equation of S.H.M. is $y = a\sin\omega t$. Therefore velocity (by differentiating it)

$(v) = \frac{dy}{dt} = a\omega\cos\omega t = a\omega\sqrt{1-\sin^2\omega t}$

$= a\omega\sqrt{1-\frac{y^2}{a^2}} = \omega\sqrt{a^2-y^2}$

28. (c) : $E = \frac{\sigma}{\epsilon_0}$

29. (a) : A cube has six faces. Therefore, electric flux coming out from any face $= \frac{Q\times10^{-6}}{6\,\varepsilon_0}$

30. (a) : Symmetry shows that resultant of three forces on unit charge at the centroid of triangle would be zero.

31. (b) : Initial P.E. at $A = V_1 = \frac{q(-Q)}{4\pi\varepsilon_0 a}$

Final P.E. at $B = V_2 = \frac{q(-Q)}{4\pi\varepsilon_0 a}$

Work done = change in P.E. $= V_2 - V_1 = 0$

32. (c) : For the same length and same material,

$\frac{R_2}{R_1} = \frac{A_1}{A_2} = \frac{3}{1}$ or $R_2 = 3R_1$

The resistance of thick wire, $R_1 = 10\ \Omega$.

The resistance of thin wire $= 3R_1 = 3 \times 10 = 30\ \Omega$.

Total resistance $= 10\ \Omega + 30\ \Omega = 40\ \Omega$

33. (d) : Apply Kirchhoff's first law.

34. (c) : $P = \frac{V^2}{R}$ or $P \propto \frac{1}{R}$; so $\frac{P_1}{P_2} = \frac{R_2}{R_1} = \frac{1}{2}$

35. (a) : The maximum power is drawn from the cell, when external resistance of cell is equal to the internal resistance *i.e.* $R = r$

Max. Power $P = \frac{E^2}{R+r} = \frac{E^2}{r+r} = \frac{E^2}{2r}$

36. (a) : Field along axis of coil $B = \frac{\mu_0 iR^2}{2(R^2+x^2)^{3/2}}$

At the centre of coil, $B' = \frac{\mu_0 i}{2R}$

$\therefore \frac{B'}{B} = \frac{\mu_0 i}{2R} \times \frac{2(R^2+x^2)^{3/2}}{\mu_0 iR^2} = \frac{(R^2+x^2)^{3/2}}{R^3}$

$\therefore B' = \frac{B\times(R^2+x^2)^{3/2}}{R^3}$

$= \frac{54\times[(3)^2+(4)^2]^{3/2}}{(3)^3} = \frac{54\times125}{27}$

or $B' = 250\ \mu$T.

37. (c) : $\because$ Charged particle is undeflected

$\Rightarrow E = vB = 2\times10^3 \times 1.5$ N/C $= 3\times10^3$ N/C

38. (c) : $B = \frac{\mu_0}{4\pi}\frac{2\pi I}{r}$

or $I = \frac{2Br}{\mu_0} = \frac{2\times\pi\times0.5}{4\pi\times10^{-7}} = 2.5\times10^6$ A

39. (d) : Magnetic moment $M = NIA = NI\pi r^2$ *i.e.* $M \propto r^2$

40. (d) : $\varepsilon = \frac{-L\,dI}{dt} = -(0.4\times10^{-3})\times\frac{(250\times10^{-3})}{0.1}$

$= -10^{-3}$ V $= -1$mV

41. (a) : Here, $R = 44\ \Omega$, $L = 8$ m H $= 8\times10^{-3}$ H

$C = 20\ \mu$ F $= 20\times10^{-6}$ F

$\omega_r = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{8\times10^{-3}\times20\times10^{-6}}}$

$\omega_r = \frac{1}{4\times10^{-4}} = \frac{10^4}{4} = 2500$ rad s^{-1}

$I_0 = \frac{E_0}{R} = \frac{\sqrt{2}\,E_v}{R} = \frac{\sqrt{2}\times220}{44}$; $I_0 = 5\sqrt{2}$ A

42. (c) : Interference in thin films causes colouring of soap bubble.

43. (a) : Here, $\frac{a}{b} = \frac{1}{3}$; $\frac{I_{max}}{I_{min}} = \frac{(b+a)^2}{(b-a)^2} = \frac{(3+1)^2}{(3-1)^2} = 4:1$

44. (d) : $\frac{1}{F} = (\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

$= (1.5-1)\left(\frac{1}{\infty}-\frac{1}{-10}\right) = \frac{1}{20}$ or $F = 20$ cm

When plane surface is silvered, $f = \frac{F}{2} = \frac{20}{2} = 10$ cm

45. (c) : $P_1 = \frac{100}{f_1} = \frac{100}{80} = 1.25$ D

$P_2 = \frac{100}{f_2} = \frac{100}{-50} = -2$ D

$P = P_1 + P_2 = 1.25 - 2 = -0.75$ D

46. (d) : $eV = \frac{1}{2}mv^2$ or $v = \sqrt{2\,eV/m}$

47. (a) : No. the half lives : $n_1 = \frac{48}{12} = 4$

$n_2 = \frac{48}{16} = 3$; $\frac{N_1}{N_0} = \left(\frac{1}{2}\right)^4 = \frac{1}{16}$; $\frac{N_2}{N_0'} = \left(\frac{1}{2}\right)^3 = \frac{1}{8}$

$\frac{N_1}{N_2}\times\frac{N_0'}{N_0} = \frac{1}{16}\times\frac{8}{1} = \frac{1}{2}$, $\frac{N_1}{N_2}\times\frac{1}{2} = \frac{1}{2}$; $\frac{N_1}{N_2} = 1:1$

48. (a) : Applying conservation of mass no. and Charge no., only (a) is correct

49. (b) : Emitter is heavily doped.

50. (b) : Output of $G_1 = (A+B)$; Output of $G_2 = \overline{A\cdot B}$;

Output of $G_3 = (A+B)\cdot\overline{A\cdot B} = (A+B)\cdot(\overline{A}+\overline{B})$

$= A\cdot\overline{A} + A\cdot\overline{B} + B\cdot\overline{A} + B\cdot\overline{B} = A\overline{B} + B\overline{A}$

[since $A\cdot\overline{A} = 0, B\cdot\overline{B} = 0$]

$y = a\cos\omega t = a\cos\frac{2\pi t}{T} = a\cos\frac{2\pi t}{1.2}$

or $\cos\frac{2\pi t}{1.2} = \frac{y}{a} = \frac{2}{4} = \frac{1}{2} = \cos\frac{\pi}{3}$

or $\frac{2t}{1.2} = \frac{1}{3}$ or $t = \frac{1.2}{6} = 0.2$ s

Time taken to move from $x = +2$ cm to $x = +4$ cm and back again $= 2t = 2 \times 0.2$ s $= 0.4$ s

27. (b) : Displacement equation of S.H.M. is $y = a\sin\omega t$. Therefore velocity (by differentiating it)

$(v) = \frac{dy}{dt} = a\omega\cos\omega t = a\omega\sqrt{1-\sin^2\omega t}$

$= a\omega\sqrt{1-\frac{y^2}{a^2}} = \omega\sqrt{a^2-y^2}$

28. (c) : $E = \frac{\sigma}{\varepsilon_0}$

29. (a) : A cube has six faces. Therefore, electric flux coming out from any face $= \frac{Q\times 10^{-6}}{6\varepsilon_0}$

30. (a) : Symmetry shows that resultant of three forces on unit charge at the centroid of triangle would be zero.

31. (b) : Initial P.E. at $A = V_1 = \frac{q(-Q)}{4\pi\varepsilon_0 a}$

Final P.E. at $B = V_2 = \frac{q(-Q)}{4\pi\varepsilon_0 a}$

Work done = change in P.E. $= V_2 - V_1 = 0$

32. (c) : For the same length and same material,

$\frac{R_2}{R_1} = \frac{A_1}{A_2} = \frac{3}{1}$ or $R_2 = 3R_1$

The resistance of thick wire, $R_1 = 10\ \Omega$.

The resistance of thin wire $= 3R_1 = 3 \times 10 = 30\ \Omega$.

Total resistance $= 10\ \Omega + 30\ \Omega = 40\ \Omega$

33. (d) : Apply Kirchhoff's first law.

34. (c) : $P = \frac{V^2}{R}$ or $P \propto \frac{1}{R}$; so $\frac{P_1}{P_2} = \frac{R_2}{R_1} = \frac{1}{2}$

35. (a) : The maximum power is drawn from the cell, when external resistance of cell is equal to the internal resistance *i.e.* $R = r$

Max. Power $P = \frac{E^2}{R+r} = \frac{E^2}{r+r} = \frac{E^2}{2r}$

36. (a) : Field along axis of coil $B = \frac{\mu_0 i R^2}{2(R^2+x^2)^{3/2}}$

At the centre of coil, $B' = \frac{\mu_0 i}{2R}$

$\therefore\ \frac{B'}{B} = \frac{\mu_0 i}{2R} \times \frac{2(R^2+x^2)^{3/2}}{\mu_0 i R^2} = \frac{(R^2+x^2)^{3/2}}{R^3}$

$\therefore\ B' = \frac{B\times(R^2+x^2)^{3/2}}{R^3}$

$= \frac{54\times[(3)^2+(4)^2]^{3/2}}{(3)^3} = \frac{54\times 125}{27}$

or $B' = 250\ \mu$T.

37. (c) : $\because$ Charged particle is undeflected

$\Rightarrow E = vB = 2\times 10^3 \times 1.5$ N/C $= 3\times 10^3$ N/C

38. (c) : $B = \frac{\mu_0}{4\pi}\frac{2\pi I}{r}$

or $I = \frac{2Br}{\mu_0} = \frac{2\times\pi\times 0.5}{4\pi\times 10^{-7}} = 2.5\times 10^6$ A

39. (d) : Magnetic moment $M = NIA = NI\pi r^2$ *i.e.* $M \propto r^2$

40. (d) : $\varepsilon = \frac{-LdI}{dt} = -(0.4\times 10^{-3})\times\frac{(250\times 10^{-3})}{0.1}$

$= -10^{-3}$ V $= -1$ mV

41. (a) : Here, $R = 44\ \Omega$, $L = 8$ m H $= 8\times 10^{-3}$ H

$C = 20\ \mu$ F $= 20\times 10^{-6}$ F

$\omega_r = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{8\times 10^{-3}\times 20\times 10^{-6}}}$

$\omega_r = \frac{1}{4\times 10^{-4}} = \frac{10^4}{4} = 2500$ rad s^{-1}

$I_0 = \frac{E_0}{R} = \frac{\sqrt{2}E_v}{R} = \frac{\sqrt{2}\times 220}{44}$; $I_0 = 5\sqrt{2}$ A

42. (c) : Interference in thin films causes colouring of soap bubble.

43. (a) : Here, $\frac{a}{b} = \frac{1}{3}$, $\frac{I_{max}}{I_{min}} = \frac{(b+a)^2}{(b-a)^2} = \frac{(3+1)^2}{(3-1)^2} = 4:1$

44. (d) : $\frac{1}{F} = (\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

$= (1.5-1)\left(\frac{1}{\infty}-\frac{1}{-10}\right) = \frac{1}{20}$ or $F = 20$ cm

When plane surface is silvered, $f = \frac{F}{2} = \frac{20}{2} = 10$ cm

45. (c) : $P_1 = \frac{100}{f_1} = \frac{100}{80} = 1.25$ D

$P_2 = \frac{100}{f_2} = \frac{100}{-50} = -2$ D

$P = P_1 + P_2 = 1.25 - 2 = -0.75$ D

46. (d) : $eV = \frac{1}{2}mv^2$ or $v = \sqrt{2eV/m}$

47. (a) : No. the half lives : $n_1 = \frac{48}{12} = 4$

$n_2 = \frac{48}{16} = 3$; $\frac{N_1}{N_0} = \left(\frac{1}{2}\right)^4 = \frac{1}{16}$; $\frac{N_2}{N_0} = \left(\frac{1}{2}\right)^3 = \frac{1}{8}$

$\frac{N_1}{N_2} \times \frac{N_0'}{N_0} = \frac{1}{16}\times\frac{8}{1} = \frac{1}{2}$; $\frac{N_1}{N_2}\times\frac{1}{2} = \frac{1}{2}$, $\frac{N_1}{N_2} = 1:1$

48. (a) : Applying conservation of mass no. and Charge no., only (a) is correct

49. (b) : Emitter is heavily doped.

50. (b) : Output of $G_1 = (A+B)$; Output of $G_2 = \overline{A\cdot B}$;

Output of $G_3 = (A+B)$. $\overline{A\cdot B} = (A+B)\cdot(\bar{A}+\bar{B})$

$= A\cdot\bar{A} + A\bar{B} + B\bar{A} + B\bar{B} = A\bar{B} + B\cdot\bar{A}$

[since $A\cdot\bar{A} = 0, B\cdot\bar{B} = 0$]

Train Your Brain

This exercise will give your brain the workout it needs.

Canadian Physics Olympaid Problems

DATA

Speed of light	$c = 3.00 \times 10^8$ m/s
Gravitational constant	$G = 6.67 \times 10^{-11}$ Nm^2/kg^2
Radius of Earth	$R_E = 6.37 \times 10^3$ km
Mass of Earth	$M_E = 6.0 \times 10^{24}$ kg
Radius of Earth's orbit	$R_{ES} = 1.50 \times 10^8$ km
Aceleration due to gravity	$g = 9.80$ m/s^2
Fundamental charge	$e = 1.60 \times 10^{-19}$ C
Mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
Mass of proton	$m_p = 1.673 \times 10^{-27}$ kg
Planck's constant	$h = 6.63 \times 10^{-34}$ Js
Coulomb's constant	$1/4\pi\varepsilon_0 = 8.99 \times 10^9$ Jm/C^2

MULTIPLE CHOICE QUESTIONS WITH ONE CORRECT OPTION

1. A child throws a ball toward the front end of an approaching train. The collision between the ball and the train is perfectly elastic. Let v be the speed of the ball with respect to the train and V its speed with respect to the ground. If the labels 'i' and 'f' refer to those speeds just before and just after, respectively, the ball hits the train, then

(a) $v_i = v_f$ and $V_i < V_f$ (b) $v_i < v_f$ and $V_i < V_f$
(c) $v_i > v_f$ and $V_i < V_f$ (d) $v_i = v_f$ and $V_i > V_f$.

2. A physics textbook of mass m rests flat on a horizontal table of mass M placed on the ground. Let $N_{a \to b}$ be the contact force exerted by body 'a' on body 'b'. According to Newton's 3rd law, which of the following is an action-reaction pair of forces?

(a) mg and $N_{\text{table} \to \text{book}}$
(b) $(m + M)g$ and $N_{\text{table} \to \text{book}}$
(c) $N_{\text{ground} \to \text{table}}$ and $Mg + N_{\text{book} \to \text{table}}$
(d) $N_{\text{ground} \to \text{table}}$ and $N_{\text{table} \to \text{ground}}$

3. At some time t, two identical balls, A and B, are set rolling without slipping at the same speed from one end of two tracks which are identical with the same horizontal length, except that track B has a dip in the path of ball B, as shown in the figure. The straight portions of the tracks are horizontal. Gravity is uniform throughout. Which ball reaches the other end first?

(a) ball A
(b) neither, since both arrive at the same time
(c) ball B
(d) ball A, but only if the dip is deep enough.

4. To a good approximation, Earth and Jupiter move around the Sun in circular orbits of 1.49×10^8 km and 7.79×10^9 km radius, respectively. What is the maximum error that can arise in the prediction of solar eclipse times (as observed from Earth) on Jupiter caused by one of its moons if one fails to take into account the variation of the relative position of the two planets?

(a) 2.6×10^3 s (b) 3.1×10^3 s
(c) 5.0×10^2 s (d) 9.9×10^2 s.

5. Experiment shows that two perfectly neutral parallel metal plates separated by a small distance d, attract each other via a very weak force, known as the Casimir force. The force, F, depends only on the Planck constant h, on the speed of light c, and on d. Which of the following has the best chance of being correct for F ?

(a) $F = hc/d^2$ (b) $F = hc/d^4$
(c) $F = hd^2/c$ (d) $F = d^4/hc$.

6. A simple pendulum of length L with a bob of mass m is taken into Earth orbit on the International Space Station. Its frequency of oscillation with respect to that on the ground is

(a) greater (b) smaller but non-zero
(c) the same (d) zero.

7. When you turn on a battery-operated portable music-playing device, how long must you leave it on for electrons leaving the negative terminal of the battery to reach the positive terminal if their path lies within good conductors?

(a) a few milliseconds (b) a few tenths of a second
(c) a few microseconds (d) a few minutes.

8. Circuit A is made of resistors connected in series to a battery; circuit B is made of resistors connected in parallel to a battery. Let P be the power drawn from the

batteries. As the number of resistors in each circuit is increased,

(a) P_A increases and P_B decreases
(b) both P_A and P_B increase
(c) P_A decreases and P_B increases
(d) P_A and P_B remain the same

9. According to a simplified but still useful model, the drag force due to air resistance on a moving car goes like the square of the car's speed v. Suppose that the maximum speed of a car is limited only by this drag force. If the power of the car's engine were increased by 50%, the top speed of the car would increase by about

(a) 50% (b) 15%
(c) 22% (d) 30%

10. A projectile is launched with an initial velocity v_i, with v_{ix} and v_{iy} the horizontal and vertical velocity components, respectively. When is there a point on its trajectory after launch where its velocity is perpendicular to its acceleration?

(a) always
(b) only if $v_{ix} \neq 0$ and v_{iy} points upward
(c) only if $v_{ix} \neq 0$
(d) always, except if $v_{ix} = 0$.

11. Three charged conducting metal spheres, of radius R_1, R_2, and R_3, are connected together by wires. Let $R_1 < R_2 < R_3$. At equilibrium, which of the following sets of relations involving the electric field strength E generated by a sphere, its potential V, and its charge Q, must hold between the spheres?

(a) $V_1 = V_2 = V_3$, $E_1 < E_2 < E_3$, $Q_1 < Q_2 < Q_3$.
(b) $V_1 = V_2 = V_3$, $E_1 > E_2 > E_3$, $Q_1 < Q_2 < Q_3$.
(c) $V_1 < V_2 < V_3$, $E_1 < E_2 < E_3$, $Q_1 = Q_2 = Q_3$.
(d) $V_1 > V_2 > V_3$, $E_1 < E_2 < E_3$, $Q_1 > Q_2 > Q_3$.

12. A ball of mass m attached to an inextensible string of length R in swung around a vertical circle just fast enough so that the string is always fully stretched. Let ΔT denote the difference between the tension in the string at the bottom and at the top of the circle, v_b and v_t the speed of the ball at the bottom and at the top, respectively. Then, taking dependence to be with respect to a set of independent variables,

(a) ΔT is independent of R, v_b and v_t
(b) ΔT is independent of R, but depends on $v_b^2 \times v_t^2$
(c) ΔT depends on R, but on neither v_b nor v_t
(d) ΔT depends on R, and $v_b^2 \times v_t^2$

13. An object of mass m hangs motionless from a vertical spring. When the object is pulled down to a new rest position, the total mechanical energy of the system

(a) increases (b) remains the same
(c) decreases
(d) may increase or decrease depending on the new position.

14. As more and more negative electric charge is being brought to a conducting sphere, inside the sphere

(a) the electric field and potential increase
(b) the electric field stays constant and the potential increases
(c) the electric field stays constant and the potential decreases
(d) the electric field increases and the potential decreases.

15. A static magnetic field of about 0.01 T in strength can erase data on the magnetic strip of a credit card. What would be roughly the minimum diameter of a long straight wire carrying a 100 A current for which your card would be safe no matter how close you take it to the wire?

(a) 0.2 mm (b) 1 mm
(c) 2 mm (d) 4 mm.

16. A string of length L is composed of two segments of equal length. One segment has linear mass density $\in_1$ and the other $\in_2 \neq \in_1$. One segment is tied to a wall, and the string is stretched by a force, applied to the other segment, which is much greater than the total weight of the string. If T_i is the tension in the i^{th} segment, and v_i the speed of a transverse wave propagating along that segment,

(a) $v_1 = v_2$ and $T_1 = T_2$ (b) $v_1 \neq v_2$ and $T_1 = T_2$
(c) $v_1 = v_2$ and $T_1 \neq T_2$ (d) $v_1 \neq v_2$ and $T_1 \neq T_2$

17. A perfectly straight portion of a uniform rope has mass M and length L. At end A of the segment, the tension in the rope is T_A; at end B it is $T_B > T_A$. The tension in the rope at a distance $L/5$ from end A is

(a) $T_B \times T_A$ (b) $(T_A + T_B)/5$
(c) $(4T_A + T_B)/5$ (d) $(T_A \times T_B)/5$.

18. Two spheres are identical except that sphere A is white whereas sphere B is black. After they have been in thermal contact long enough with each other and their surroundings, in the visible range,

(a) A radiates less than B
(b) Both emit the same amount of radiation
(c) A radiates more than B
(d) A radiates more than B only if its temperature is high enough.

19. An aircraft bound for Vancouver and coming from

Montreal is flying due west. Its body and wings are covered in aluminium. At some point on its flight path, the Earth's magnetic field points north and downward. The point on the plane's exterior which is then at the highest potential is

(a) the nose (front) (b) the tail (back)
(c) the tip of the right wing
(d) the tip of the left wing

20. You are on the shore of a canal of uniform width d and want to reach a point a distance $L > d$ away along the other shore as quickly as possible. To achieve this, you first run along the shore at constant speed v_1, then jump in the canal and swim directly toward your target at constant speed $v_2 < v_1$, both being your maximum speeds. The water in the canal is motionless. The angle of your trajectory in the water with respect to the shore must obey

(a) $\cos\theta = v_1/v_2$ (b) $\cos 0 = \sqrt{v_1^2/v_2^2} << 1$
(c) $\cos\theta = 1 << d/L$ (d) $\cos\theta = v_2/v_1$.

21. Exactly half of a rectangular conducting loop lies in a uniform magnetic field perpendicular to the plane of the loop. At some point in time, the magnitude of the magnetic field starts rapidly decreasing. While this is happening, which of the followings statements most accurately describes the effect on the loop?

(a) The loop is pulled into the magnetic field
(b) The loop is pushed out of the magnetic field
(c) The loop starts rotating
(d) The behaviour of the loop cannot be determined unless the direction of the magnetic field is completely specified.

22. Two otherwise identical spaceships have different solar sails: sail A is a perfect reflector, sail B is a perfect absorber. Each starts at the same distance from the Sun and travels radially outward. Let Δp_A and Δp_B be the momentum gained by the ships after travelling equal distances. Then

(a) $\Delta p_A = \Delta p_B$ (b) $\Delta p_A > \Delta p_B$
(c) $\Delta p_A < \Delta p_B$ (d) $\Delta p_A = \Delta p_B = 0$.

23. If there were only one transmitter, and you were separated from this transmitter by the many tall buildings to be found in downtown Toronto, spaced about 30 m apart on average, with which of the following would you be most likely to experience dead spots (places with very poor or no reception)?

(a) AM radio stations (frequency 1 MHz)
(b) FM radio stations (frequency 100 MHz)
(c) cell phones (frequency 1000 MHz)
(d) all of the previous equally.

24. A horizontal cathode ray tube (CRT) is set so that its electron beam produces a spot of light at the centre of the screen when no external electromagnetic field is present. When you look straight at the screen, however, you discover that the spot, instead of being at the centre as it should, is shifted a bit to the right. Suspecting what the cause of this deflection may be, you rotate the CRT by 180° around its vertical axis. Facing the screen, you find that the spot of light is still shifted to right of centre by the same distance as before. You conclude that the CRT is immersed in

(a) an electric field directed horizontally to the left with respect to the screen's initial position
(b) an electric field directed horizontally to the right with respect to the screen's initial position
(c) a magnetic field directed vertically upward with respect to the screen's initial position
(d) a magnetic field directed vertically downward with respect to the screen's initial position

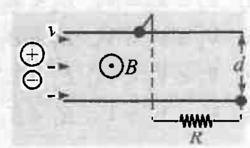
25. Light rays from a very distant source travel along the $+x$ direction. Two identical thin lenses with focal length $f > 0$ and their optical axis along x, sit, one at $x = 0$, and the other at $x = d < f$. Where do the rays focus?

(a) $d + \dfrac{f(f+d)}{2f-d}$ (b) $d + \dfrac{f(f-d)}{d}$
(c) $d + \dfrac{f(f-d)}{2(f+d)}$ (d) $d + \dfrac{f^2}{(2f-d)}$

SHORT ANSWER TYPE QUESTIONS

Problem 1

A magnetohydrodynamic (MHD) generator is a device that converts part of the kinetic energy of a streaming hot gas into electrical energy. At its operating temperature of between 2000 and 3000 K, the gas is readily ionised. As schematically shown in the figure, the ions and electrons enter a region between two electrodes (here, parallel conducting plates of area A separated by a gap d) in which a uniform and constant magnetic field B has been set up, pointing straight out of the page. Their initial velocity v is parallel to the plates. A resistor R is connected to the plates. The magnetic field is strong enough that many charged particles will hit the electrodes and charge them before they can exit. This creates a time-varying potential difference V between the plates.



(a) On a diagram, display all the forces acting on a positive ion at some generic position between the plates. Use your diagram to show that the ion experiences a braking force as soon as its velocity has a component transverse to the plates.

(b) Then, a crude approximation, assume that any electric field E arising from the process is uniform everywhere between the plates. Assume also that the transverse component of the velocity of the charges remains everywhere much smaller than its longitudinal component, and that the latter therefore is pretty uniform. The gas obeys a generalised Ohm's law, according to which $J = \sigma(E + v \times B)$, where J is the transverse current density between the plates and σ is the conductivity of the gas.
Obtain an expression for the current I flowing through the resistor in terms of v, B, and R.

(c) Derive an expression for the output voltage V that does not explicitly contain R.

Problem 2

A 1000 kg satellite is orbiting the Earth at an altitude of 400 km. It receives electrical power from a solar panel of area A = 10 m^2. At this altitude, Earth's atmosphere is very tenuous, with a density $\rho = 10^{-11}$ kg/m^3. Nevertheless, over time, the friction force generated by collisions of the molecules and the panel might cause the satellite to lose altitude.

(a) Assume that in such collisions, the molecules become embedded in the solar panel. If the satellite is moving at speed v, find an expression for the maximum retarding force on the solar panel in terms of ρ and of the radius of the satellite's orbit. Make any other reasonable assumption.

(b) Estimate how much altitude the satellite might lose over one week because of this friction. If you make assumptions, do not forget to justify them briefly.

(c) Somebody claims that as the satellite loses altitude it also loses speed because of the friction. Comment briefly.

Problem 3

In a mood for some physics as you look at a sailboat on a lake, you wonder about its stability when a strong wind blows from the side. The sailboat leans over in the wind and the question in whether its keel can prevent it from being blown over completely.

Analyze the stability of the sailboat using the following oversimplified model.

Consider the hull of the sailboat as an straight hollow cylinder. On top of this cylinder and perpendicular to it sits a mast carrying a square sail, assumed to be always parallel to the length of the hull. Attached to the bottom of the hull is a keel in the shape of a square always parallel to the sail. A heavy lead weight forms the bottom of the keel under water. Other than the lead weight, consider mast, sail, hull, and keel to be weightless. Somewhat unrealistically (it would make tacking difficult), you can also assume that the sail extends all the way from the bottom to the top of the mast.

(a) Establish a relationship between wind speed and the angle θ the mast will tilt away from its initial upright position when a wind with speed v blows perpendicular (initially) to the sail. Other assumptions may be made so long as they are explicity stated and, as much as possible, justified.
In this simplified model, is this boat stable in all wind speeds? Since you may not be able to find a general solution for the angle θ as a function of v, you are welcome to obtain solution valid only for small θ or for large θ. The expansion $(1 + x)^n = 1 + nx + ...$ for $x << 1$ may be useful.

(b) The following data, lossely based on the *Catalina Capri* 16, are given for a small sailboat. Area A of sail is 12 m^2, mass M of lead weight 190 kg, depth d of keel below water level, technically known as draft, 0.75 m, height h of mast 6.6 m, specific gravity of lead, supposed to be the part at the bottom of the keel that acts as a stabiliser, 11.3. Also, air density is 1.2 kg/m^3.
With these date, at what wind speed will θ be 30°? 60°?

SOLUTIONS

1. (a) : In elastic collision, linear momentum is conserved.

Now considering momentum of ball with respect to train,

$p_i = mv_i$, $\quad p_f = mv_f$

m is mass of ball.

$\because \; p_i = p_f; \quad \therefore mv_i = mv_f, \quad \therefore v_i = v_f$

Now considering momentum of ball with respect to ground.

$p_i = mV_i; \quad p_f = mV_f$

To find V_f, we use the relation,

$$V_1 = \frac{(m_1 - m_2)u_1}{m_1 + m_2} + \frac{2m_2u_2}{m_1 + m_2}$$

$m_1 = m$ (mass of ball)

$m_2 = M$ (mass of train)

$u_1 = V_i$ (initial velocity of ball with respect to ground)

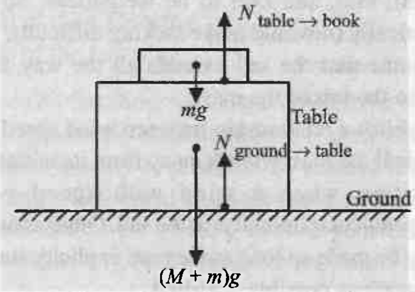
$u_2 = V$ (initial velocity of train with respect to ground)

$v_1 = V_f$ (final velocity of ball with respect to ground)

$\therefore \quad V_f = \dfrac{(m-M)V_i}{m+M} + \dfrac{2mV}{(m+M)}$

it is clear, $V_f > V_i$ *i.e.* $\boxed{V_i < V_f}$
Hence option (a) is correct.

2. (d) :



If $N_{\text{ground}\to\text{table}}$ is action, then its reaction must be $N_{\text{table}\to\text{ground}}$.

3. (c) : Speed of ball A remains same throughout its path but speed of ball B increases as it falls through the dip. As speed of ball B increases, its will take less time than A to reach other end.

4. (d)

5. (a) : $F \propto h^a c^b d^c$

$F = k\, h^a c^b d^c$ .....(i)

where k is a constant.

$[F] = [h]^a\, [c]^b\, [d]^c$

$ML\,T^{-2} = (ML^2\,T^{-1})^a . (LT^{-1})^b\, (L)^c$

$ML\,T^{-2} = M^a . L^{2a+b+c} . T^{-a-b}$

Equating power on both sides, we get

$\boxed{a = 1}$ ...(ii)

$2a + b + c = 1$ ...(iii)

$-a - b = -2$ ...(iv)

From (ii) & (iv), $-1 - b = -2$; $\quad -(1 + b) = -2$

$1 + b = 2$ $\boxed{b = 1}$

From (iii), $2a + b + c = 1$

or $\quad 2 \times 1 + 1 + c = 1$; $\ 2 + 1 + c = 1$

$c = 1 - 1 + 2$; $\boxed{c = -2}$

Put value of a, b and c in (i) we get

$F = k\, h^1 c^1 . d^{-2}$; $\quad F = k\dfrac{hc}{d^2}$

Hence, the best change of correct F is $F = \dfrac{hc}{d^2}$

6. (d) : Time period of simple pendulum, $T = 2\pi\sqrt{\dfrac{l}{g}}$

Frequency of simple pendulum, $\upsilon = \dfrac{1}{2\pi}\sqrt{\dfrac{g}{l}}$

$\because \quad g = 0$ at International space station

$\therefore \quad \upsilon = 0.$

7. (d)

8. (c) : Circuit A: Let n equal resistors R are connected in series to a battery V volt.

$\therefore \quad$ Equivalent resistance in series, $R_s = nR$

$\therefore \quad$ Power of circuit A is $P_A = \dfrac{V^2}{R_s} = \dfrac{V^2}{nR}$

$P_A = \dfrac{V^2}{nR}$ ...(i)

Circuit B : Let n equal resistors are connected in parallel to a battery.

Equivalent resistance in parallel

$R_p = \dfrac{R}{n}$

$\therefore \quad$ Power of circuit B is,

$P_B = \dfrac{V^2}{R_p} = \dfrac{V^2}{\frac{R}{n}} = n\dfrac{V^2}{R}$ ...(ii)

Now, $P_A \propto \dfrac{1}{n}$ and $P_B \propto n$

As n increases, P_A decreases and P_B increases
Hence, option (c) is correct.

9. (b) : Drag force due to air resistance,

$F \propto v^2$ (given)

where v is top speed of car.

$\therefore \quad F = kv^2$ ...(i)

where k is a constant.

Now, power of car engine, $P = Fv$. $\because P - kv^2.v$

using (i)

$\therefore \quad P = kv^3$

Taking log both sides we get $\log P = \log k + 3\log v$

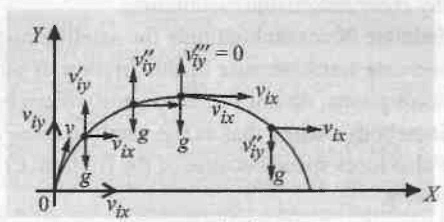
On differentiating we have,

$\dfrac{1}{P} \cdot dP = 0 + 3\dfrac{1}{v}\, dv$; $\quad \dfrac{dP}{P} = \dfrac{3dv}{v} \Rightarrow 50\% = 3\left(\dfrac{dv}{v}\right)$

$\therefore \quad \dfrac{dv}{v} = \dfrac{50}{3}\% = 16.6\%$ (max).

Hence, top speed of car may increase by 15%

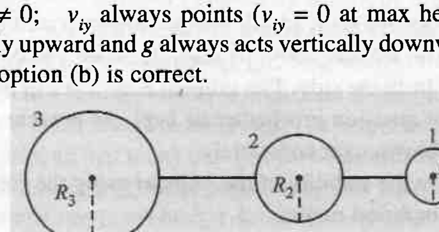
10. (b) :



v_{ix} remains constant through the journey.

i.e $\quad v_{ix} \neq 0$; $\quad v_{iy}$ always points ($v_{iy} = 0$ at max height) vertically upward and g always acts vertically downward. Hence, option (b) is correct.

11. (b) :



$C_1 = 4\pi\varepsilon_0\, R_1$

$C_2 = 4\pi\varepsilon_0 R_2$
$C_3 = 4\pi\varepsilon_0 R_3$
After connecting the wires, the system of spheres acquire a common potential. (V)
i.e. $V = V_1 = V_2 = V_3$. Now $C_1 = Q_1 V$
$4\pi\varepsilon_0 R_1 = Q_1 V$

$$Q_1 = \frac{4\pi\varepsilon_0}{V} \cdot R_1;\ Q_2 = \frac{4\pi\varepsilon_0}{V} \cdot R_2;\ Q_3 = \frac{4\pi\varepsilon_0}{V} \cdot R_3$$

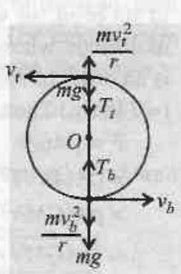
As $R_1 < R_2 < R_3$
$\therefore\ Q_1 < Q_2 < Q_3$

$$\text{Again } E = \frac{KQ}{R^2} \Rightarrow E = K \cdot \frac{4\pi\varepsilon_0 R}{V} \cdot \frac{1}{R^2} = K \cdot \frac{4\pi\varepsilon_0}{V} \cdot \frac{1}{R}$$

$\therefore\ E \propto \frac{1}{R}$

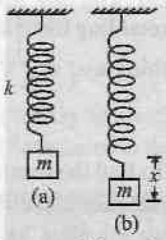
i.e. smaller the radius, higher the electric field with common potential
$\therefore\ E_1 > E_2 > E_3$
Hence, option (b) is correct.

12. (a) : $v_t = \sqrt{rg}$



$v_b = \sqrt{5rg}$
$T_t = 0$
$T_b = 5mg$
Change in tension,
$\Delta T = T_b - T_t$
$\Delta T = 5mg - 0$
$\Delta T = 5mg$
ΔT is independent of R, v_b and v_t.

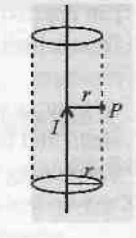
13. (a) : Work done by spring $-\frac{1}{2}kx^2$



Mechanical energy of spring-mass system in (b) goes on increasing with the elongation x.

14. (c)

15. (d) : Magnetic field at P due to a long straight wire carrying current I, is



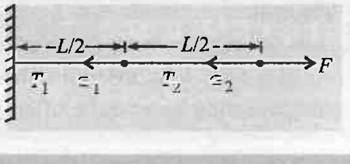
$$B = \frac{\mu_0}{4\pi} \cdot \frac{2I}{r} \Rightarrow 0.01 = \frac{10^{-7} \times 2 \times 100}{r}$$

$$\Rightarrow\ 10^{-2} = \frac{2 \times 10^{-5}}{r}$$

$$\therefore\ r = \frac{2 \times 10^{-5}}{10^{-2}} = 2 \times 10^{-3}\,\text{m}$$

$\therefore\ r = 2$ mm
$\therefore$ diameter of wire, $d = 2r$; $d = 4$ mm

16. (b) : Tension on the string strictly depends on value of external force applied on it here, external force F is constant and very large. Hence, $T_1 = T_2$.
Further, we know that, velocity of transverse wave on string is given by



$$v = \sqrt{\frac{T}{\in}}$$

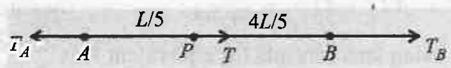
where $\in$ is linear mass density.

$\therefore\ v_1 = \sqrt{\frac{T}{\in_1}}$ and $v_2 = \sqrt{\frac{T}{\in_2}}$ As $\in_1 \neq \in_2$

$\therefore\ v_1 \neq v_2$

17. (c) : Mass of rope $= M$
Length of rope $= L$
For entire rod AB, $T_B - T_A = Ma$ ...(i)

At point P, $T - T_A = \frac{M}{L}\left(\frac{L}{5}\right)a$



$$T - T_A = \frac{M}{5}a$$

$$T - T_A = \frac{1}{5}[T_B - T_A] \quad \text{using (i)}$$

$$T - T_A = \frac{T_B}{5} - \frac{T_A}{5}$$

$$T = \frac{T_B}{5} + T_A - \frac{T_A}{5} = \frac{T_B}{5} + \frac{4T_A}{5}$$

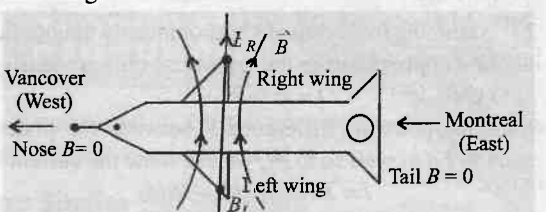
$$T = \frac{(4T_A + T_B)}{5}$$

18. (a) : A black body is a perfectly absorber as well as a perfectly radiator.
Therefore, Body A radiates less than body B.

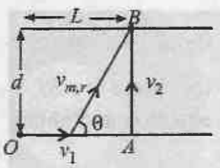
19. (c) : Magnetic field at nose and tail of aircraft is zero. Magnetic field at right wing of aircraft (B_R) is greater than magnetic field at left wing of aircraft (B_L)

$B_R > B_L$

Hence, right wing of aircraft is at higher potential than its left wing.



20. (d) : $\tan\theta = \frac{v_2}{v_1}$



Given that: $v_2 < v_1$
$\therefore$ θ is small

$$\therefore\ \cos\theta = \frac{v_2}{v_1}$$

21. (a)

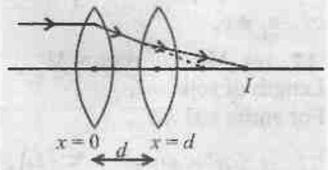
22. (b) : Perfect reflector spaceships suffers greater change in momentum than perfect absorber spaceships.
i.e $\Delta p_A > \Delta p_B$.

23. (c) **24.** (c)

25. (d) : If f' is equivalent focal length of combination, then,

$$\frac{1}{f'}=\frac{1}{f}+\frac{1}{f}-\frac{d}{f\cdot f}$$

$$=\frac{2}{f}-\frac{d}{f^2}$$



$$\frac{1}{f'}=\frac{2f-d}{f^2}$$

$$\therefore \quad f'=\frac{f^2}{(2f-d)}$$

Now, using lens formula for equivalent lens $\frac{1}{v}-\frac{1}{u}=\frac{1}{f'}$

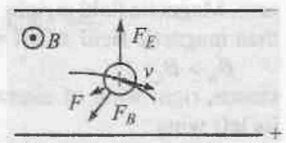
$$\frac{1}{v}-\frac{1}{\infty}=\frac{1}{\frac{f^2}{(2f-d)}}=\frac{2f-d}{f^2}$$

$$\frac{1}{v}=\frac{2f-d}{f^2} \quad \text{or} \quad v=\frac{f^2}{(2f-d)}$$

Hence, the rays focussed at a distance $\left[d+\frac{f^2}{(2f-d)}\right]$ from $x = 0$.

Problem 1

(a) In the figure below, the electric force F_E and the magnetic force F_B on the ion are displayed. The resultant net force F has a centripetal component (perpendicular to the trajectory), which does not change v, and a tangential component opposite v which slows down the ion.



(b) Assuming that v remains approximately longitudinal, in a first approximation the transverse current density is

$$J = \sigma\,(vB - E)$$

Since the potential difference V between the plates is equal to Ed as well so to RI, we can write the current I as

$$I = JA = A\sigma(vB - IR/d)$$

Solving for I gives

$$\boxed{I=\frac{vBd}{d/\sigma A+R}}$$

(c) Since $V = RI$, we can solve for RI in the next-to-last equation and obtain

$$\boxed{V = vBd - Id/\sigma A}$$

Problem 2.

(a) The force on the panel, or the rate momentum change, is equal to the product of the number of molecules that strike the panel per unit of time with the change of momentum of individual particles when they collide with the panel. Since the molecules are absorbed, they come to rest and the change is equal to the incident momentum itself.

If n is the number of molecules per unit volume, the number that strike the panel per unit of time, or flux, is equal to the product of n with the surface A of the panel and the component of the molecule's velocity perpendicular to the panel. The momentum of an individual incident molecule perpendicular to the panel is its mass m times the component of its velocity perpendicular to the panel. Since $nm = \rho$, the mass density of the molecules, this gives $F = \rho A v^2$, with v the average speed of the molecules with respect to the panel, when the flux is perpendicular to it.

We assume that this average speed is that of the satellite in its orbit, ie we neglect the intrinsic motion of the molecules, whose average speed with respect to the Earth is an order of magnitude lower than the satellite's speed (~ 7 km/s.) Then, with r the orbital radius of the satellite,

$$F = \rho A\omega^2 r$$

$$= \rho A(4\pi^2/T^2)r \qquad (T \text{ is the period of the orbit})$$

$$= \rho A(GM/r^2)r \qquad (\text{Kepler's third low})$$

$$= \boxed{\rho AGM/r}$$

(b) The rate what which energy is lost because of this retarding force is $P = F\cdot v = -F\omega r$. Again, from Kepler's third law, $\omega=\sqrt{GM/r^3}$, and we obtain

$$\boxed{P=-\rho A(GM/r^3)^{3/2}}$$

To find the resulting rate of change in radius, we observe that the total energy of the satellite is $E = -GMm/2r$. If we calculate $\Delta E = E_2 - E_1$ corresponding to $\Delta r = r_2 - r_1$, we see that if we can assume that $\Delta r << r_1, r_2$, then we can approximate $r_2 \approx r_1 = r$, so that $\Delta E = (GMm/2r^2)\Delta r$, from which immediately follows

$$\Delta r = (2r^2/GMm)P\Delta t$$

so long as we can assume that the rate of energy loss is small and constant on the time scale of interest.

Combining with the second boxed equation above yields.

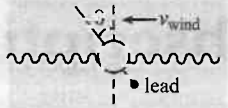
$$\boxed{\Delta r=-\frac{2\rho A}{m}\sqrt{GMr}\,\Delta t}$$

Inserting numbers and $\Delta t \sim 6\times10^5$ s (a week), gives $\boxed{\Delta r \approx 6 \text{ km}}$

The answer is consistent with out assumption of reasonably slow orbit decay, but it also shows that the satellite would not stay very long in orbit unless it gives itself a small compensating boost quite often.

Problem 3.

(a) Similar to problem 2, the initial force exerted by the wind on the sail is $F = \rho A v^2$, where ρ is air density, A the area of the sail, and v the wind speed.



When the mast is tilted at angle θ with respect to the vertical, the component of the force perpendicular to the sail is $\rho A v^2 \cos^2\theta$. This force exerts a torque about the hull, with moment arm $\frac{1}{2}h \cos\theta$. The total torque of the wind force is then

$$\tau_w = \frac{1}{2}\rho A h v^2 \cos^3\theta$$

A counter-torque is provided by the lead mass at the bottom of the keel. We should take into account the buoyancy of the lead. If M is the mass of the lead, then its net weights is $(1 - \rho_{water}/\rho_{lead})\, M\, g$. The moment arm is $d \sin\theta$, so that the opposing torque from the keel is

$$\tau_k = \left(1 - \frac{\rho_{water}}{\rho_{lead}}\right) M\, g\, d \sin\theta$$

Imposing the condition for equilibrium, $\tau_w = \tau_k$, and solving for v, we obtain

$$\boxed{v = \left[\frac{2\left[1 - \frac{\rho_{water}}{\rho_{lead}}\right] Mgd\sin\theta}{\rho A h \cos^3\theta}\right]^{1/2}}$$

where θ is not the equilibrium angle.

Writing the answer in this form makes it easy to check that dimensions are correct, since the denominator in the bracket is obviously a mass, and it is well known that v has the same dimensions as $\sqrt{g\,d}$

Let us rewrite the previous expression after inserting $\cos^2\theta = 1 - \sin^2\theta$.

$$(1 - \sin^2\theta)^3 = -\frac{B^2}{v^4}\sin^2\theta$$

$$\text{where} \quad B = \frac{2\left(1 - \frac{\rho_{water}}{\rho_{lead}}\right) M\, gd}{\rho A h}$$

This is a cubic equation which is not that easily solved if you don't have a good calculator or a computer at hand. Nevertheless, one can look at the small angle solution using the binomial expansion $(1 - \sin^2\theta)^3 \approx 1 - 3\sin^2\theta$. Then, in the limit of small θ angles,

$$\sin\theta \approx \frac{1}{\sqrt{(3 + B^2/v^4)}}$$

One sees that θ increases smoothly with v, as expected. In the large-angle approximation, for θ approaching 90°, it is best to recast out result for v in terms of $\cos\theta$.

$$\frac{v^2}{B^2} = \frac{1 - \cos^2\theta}{(\cos^2\theta)^3} \approx \frac{1}{(\cos^2\theta)^3} \text{ in the limit of large } \theta$$

Then we get immediately $\sin\theta \approx \sqrt{1 - (B^2/v^4)^{1/3}}$

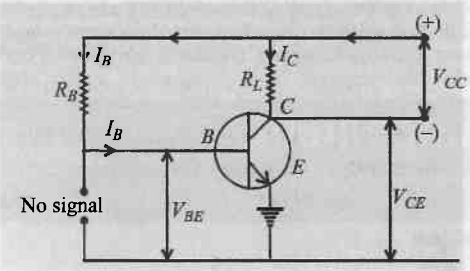
This is seen to approach 1 smoothly more important, there exists a solution. Thus, the range $0 < v < \infty$ maps smoothly to the range $\theta < \theta < 90°$, so that equilibrium can be maintained at any finite speed.

(b) Inserting the date yields $\boxed{v = 4.5 \text{ m/s}}$ for $\theta = 30°$ and $\boxed{v = 13.6 \text{ m/s}}$ for $\theta = 60°$

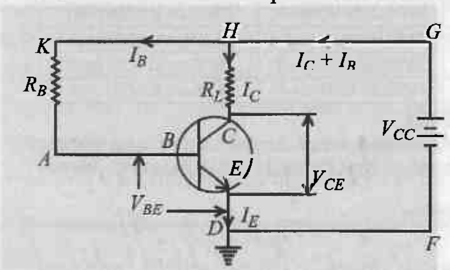
Thought Provoking Problems in Electronics

By : Prof. Rajinder Singh Randhawa*

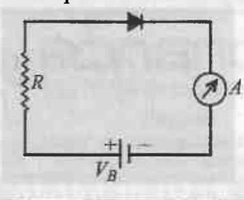
1. An *npn* transistor in a common emitter mode is used as a simple voltage amplifier with a collector current of 4 mA. One terminal of an 8 V battery is connected to the collector through a load resistance R_L and to the base through a resistance R_B. The collector-emitter voltage V_{CE} = 4 V, base - emitter voltage V_{BE} = 0.6 V and the base current amplification factor β_{ac} = 100. Find the values of R_L and R_B.



2. In circuit shown in figure, the base current I_B=5 μA, base resistor R_B = 1×10^6 Ω, collector resistor R_C = 1.1×10^3 Ω, the collector current I_C = 5 mA and dc voltage in the collector circuit V_{CC} = 6.0 V. Can this circuit be used as an amplifier?



3. A silicon diode is connected to a resistor R and a battery of voltage V_B as shown in figure. The knee point of its I-V characteristics is 0.7 V. Assume that the diode requires a minimum current of 1 mA to attain a value higher than the knee point. Also assume that the voltage V across the junction is independent of the current above the knee point.



(a) If V_B = 5 V, what should be the maximum value of R so that the voltage V is above the knee point voltage?

(b) In V_B = 5 V, what should be the value of R in order to establish a current of 5 mA in the circuit?

(c) In V_B = 6 V, what is the power dissipated in the resistor R and the diode when a current 5 mA flows in the circuit?

(d) If R = 1 kΩ, what is the minimum voltage V_B required to keep the diode above the knee point?

4. A semiconductor has an electron concentration of 8×10^{13} cm^{-3} and a hole concentration of 5×10^{12} cm^{-3}.

(a) Is the semiconductor *n*- or *p*-type ?

(b) What is the resistivity of the semiconductor?

Given, electron mobility (μ_e) = 2.3×10^4 cm^{2}V^{-1}s^{-1} and hole mobility (μ_h) = 100 cm^{2}V^{-1}s^{-1}.

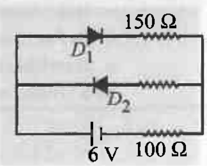
5. When the plate voltage of a triode is increased from 230 V to 250 V. The control grid voltage is changed from –3 V to –3.4 V to maintain the constant current. If the plate resistance at this point is 5000 Ω, find the amplification factor (μ) and mutual conductance (g_m)?

6. The base current of a transistor is 105 μA and collector current is 2.05 mA.

(a) Determine the value of β, I_E and α.

(b) A change of 27 μA in the base current produces a change of 0.65 mA in the collector current. Find β_{ac}?

7. The circuit shown in figure contains two diodes each with a forward resistance of 50 Ω and with infinite reverse resistance. It the battery voltage is 6 V, find the current through the 100 Ω resistance.



8. The saturation current density of a *P-N* junction germanium diode is 250 mA/m^2 at 300 K. Find the

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voltage that would have to be applied across the junction to cause a forward current density 10^5 Am^{-2} to flow. (Boltzmann's constant $k = 1.38 \times 10^{-23}$ J/K).

9. An audio signal of 10,000 Hz modulates a carrier generated by a tank circuit comprising of a capacitor of 1×10^{-9} F and a coil of 10×10^{-6} H. Find the frequency of side bands.

SOLUTIONS

1. As $\beta_{dc} = \frac{I_C}{I_B}$ $\therefore I_B = \frac{I_C}{\beta_{dc}} = \frac{4\times10^{-3}\text{ A}}{100} = 4\times10^{-5}\text{ A}$

$\therefore V_{CC}$ = potential drop across $R_B + V_{BE} = I_B R_B + V_{BE}$

$$\therefore R_B = \frac{V_{CC} - V_{BE}}{I_B} = \frac{(8-0.6)}{4\times10^{-5}} \simeq 1.85\times10^5\,\Omega$$

Also, from fig., V_{CC} = potential drop. across $R_L + V_{CE}$
$= I_C R_L + V_{CE}$

$$\therefore R_L = \frac{V_{CC} - V_{CE}}{I_C}$$

$$R_L = \frac{8-4}{4\times10^{-3}} = 1000\ \Omega$$

2. As we know that, a transistor circuit can be used as an amplifier if the emitter-base junction is forward-biased and the base-collector junction reverse biased. Applying Kirchhoff's loop rule to the loop *ABEDFGHKA*, we have

$V_{CC} = V_{BE} + I_B R_B$ ($V_{BE} \rightarrow$ base emitter voltage)

$V_{BE} = V_{CC} - I_B R_B = 6 - (5 \times 10^{-6}) \times (1 \times 10^6) = +1$ V

Again apply Kirchhoff's law to the loop *EDFGHCBE*, we get

$V_{CC} = V_{CE} + I_C R_L \quad \Rightarrow V_{CE} = V_{CC} - I_C R_C$

$V_{CE} = 6 - (5 \times 10^{-3}) \times (1.1 \times 10^3) = +0.5$ V

The collector is + 0.5 V w.r.t. the emitter and the base is + 1.0 V w.r.t. emitter. So that the base is $(1 - 0.5) = +0.5$ V w.r.t. collector.

$\therefore$ Both the emitter-base and base-collector junctions are forward-biased. Hence the circuit cannot be used as an amplifier.

3. (a) Let $V_R \rightarrow$ Voltage across resistor
$V \rightarrow$ Voltage across the junction diode.

Then, $V_B = V_R + V$.

$\therefore \quad V_R = V_B - V = 5 - 0.7 = 4.3$ V

From Ohm's law, $V_R = IR$. Since V_R is fixed, when I is minimum (I_{min}), R should be maximum (R_{max}), such that

$I_{min} \times R_{max} = 4.3$ V

$$\therefore \quad R_{max} = \frac{4.3}{1\times10^{-3}\text{ A}} = 4.3\times10^3\,\Omega$$

(b) Now $V = 0.7$ V as in part (a), since it is independent of the current above the knee point. Also $V_B = 5$ V

$\therefore \quad V_R = V_B - V = 5 - 0.7 = 4.3$ V

But; $R = \frac{V_R}{I} = \frac{4.3}{5\times10^{-3}} = 860\,\Omega$

(c) In this case, $V_B = 6$ V, But $V = 0.7$ V (as before)

$\therefore \quad V_R = 6 - 0.7 = 5.3$ V

As we know that power dissipated equals current times voltage. The current in the circuit is

$I = 5$ mA.

$\therefore$ Power dissipated $= V_R \times I = 5.3 \times (5 \times 10^{-3})$
$= 26.5$ mW.

and the power dissipated in the diode is
$= I \times V = (5 \times 10^{-3}) \times 0.7 = 3.5$ mW.

(d) $R = 1\ \text{k}\Omega = 1000\ \Omega$. To keep the diode above the knee point, a minimum current of

$I_{min} = 1\text{ mA} = 10^{-3}$ A must flow in the circuit.

$\therefore$ Minimum voltage V_B required is; $V_B = I_{min} \times R + V$.
$= (1 \times 10^{-3}) \times 1000 + 0.7 = 1 + 0.7 = 1.7$ V.

4. (a) Since the electron concentration is higher than the hole concentration, it is an n-type semiconductor.

(b) The resistivity of semiconductor

$$\rho = \frac{1}{e(n_e\mu_e + n_h\mu_h)}$$

$$\rho = \frac{1}{(1.6\times10^{-19})[8\times10^{19}\times2.3 + 5\times10^{18}\times1\times10^{-2}]}$$

$$= \frac{1}{29.44}$$

$\rho \approx 3.39 \times 10^{-2}\ \Omega\text{m}$

The power of the waterfall is nothing but a lot of drops working together

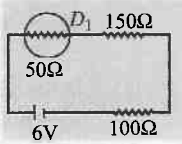
-Anon

5. We know that $\mu = \left(\frac{\partial V_a}{\partial V_g}\right)_{i_a \text{ is const.}}$

Here $\partial V_a = 250 - 230 = 20$ volts

$\partial V_g = 3.4 - 3.0 = 0.4$ V

$\therefore \quad \mu = \frac{20}{0.4} = 50$



Also

$$g_m = \frac{\mu}{r_p} = \frac{50}{5000} = \frac{1}{100} = 10^{-2} \text{ mho}$$

6. (a) $\beta = \frac{I_C}{I_B} = \frac{2.05\times10^{-3}}{105\times10^{-6}} = 19.5$

Now, $I_E = I_B + I_C = 105 \times 10^{-6} + 2.05 \times 10^{-3}$ $= 2.155 \times 10^{-3}$ A $= 2.155$ mA

$\beta = \frac{\alpha}{1-\alpha}$ or $19.5(1-\alpha) = \alpha$

Solving, we get $\boxed{\alpha = 0.95}$

(b) $\beta_{ac} = \frac{\delta I_C}{\delta I_B} = \frac{0.65\times10^{-3}}{27\times10^{-6}} = \frac{0.65}{27}\times10^3 = 24.07$

7. Diode D_1 is forward biased and offers a resistance of 50 Ω. Diode D_2 is reverse biased and as its corresponding resistance is infinite, no current flows through it. Now the equivalent circuit is shown in figure. As all the three resistances are in series, the current through them is $I = \frac{6\text{ V}}{(50+150+100)\,\Omega} = 0.02$ A

8. As we have $I = I_S\left(e^{\frac{eV}{\eta kT}} - 1\right)$

For Ge, $\eta = 1$

Put $\eta = 1$ and dividing both sides by area,

$$\frac{I}{A} = \frac{I_S}{A}\left(e^{eV/kT} - 1\right) \Rightarrow J = J_S\left(e^{eV/kT} - 1\right)$$

Given $J_S = 250 \times 10^{-3}$ Am^{-2}, $J = 10^5$ Am^{-2}

$$\therefore \quad e^{eV/kT} - 1 = \frac{J}{J_S} = \frac{10^5}{250\times10^{-3}} = 4\times10^5$$

$$\frac{eV}{kT} = \log_e(4\times10^5) = 12.9$$

$$V = \frac{12.9\times1.38\times10^{-23}\times300}{1.6\times10^{-19}} = 0.33 \text{ V}$$

9. $\upsilon_C = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\times3.14\times\sqrt{(10\times10^{-6})\times(1\times10^{-9})}}$

$\upsilon_C = 1592$ kHz

Freq. of side bands $= (1592 + 10) = 1602$ kHz and $(1592 - 10) = 1582$ kHz.

1. Who can participate

If you have taken any of the exams given below and possess plenty of grey cells, photographic memory then you are the right candidate for this contest. All you have to do is write down as many questions (with all choices) you can remember, neatly on a paper with name of the exam, your name, address, age, your photograph and mail them to us.

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- *Kindly note that each question should be complete.*
- *Payment will be made only for complete questions.*
- *Preference will be given to the reader sending the maximum complete and correct questions. Other conditions apply. The decision of the Editor, MTG shall be final and binding.*

Exam on 27.04.2008

Practice Paper
AIEEE - 2008

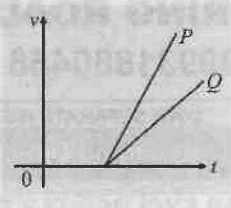
1. If e is the charge, V the potential difference, T the temperature, the units of eV/T are the same as of
(a) Planck's constant (b) Stefan's constant
(c) Boltzmann constant
(d) gravitational constant.

2. A circular railway track of radius r is banked at angle θ so that a train moving with speed v can safely go round the track. A student writes : $\tan\theta = \frac{rg}{v^2}$
Why this relation is not correct?
(i) equality of dimensions does not guarantee correctness of the relation
(ii) dimensionally correct relation may not be numerically correct
(iii)the relation is dimensionally incorrect
(a) (i) and (ii) (b) (ii) and (iii)
(c) (iii) and (i) (d) (i), (ii) and (iii)

3. A quantity is represented by $X = M^a L^b / T^c$. The percentage error in measurement of M, L and T are α %, β %, γ % respectively. The percentage error in X would be
(a) $(\alpha a + \beta b + \gamma c)$ % (b) $(\alpha a - \beta b + \gamma c)$ %
(c) $(\alpha a - \beta b - \gamma c) \times 100\%$ (d) none of the these

4. If $\bar{i}$, $\bar{j}$ and $\bar{k}$ are unit vectors along x, y and z-axis respectively, the angle θ between the vector $\bar{i} + \bar{j} + \bar{k}$ and vector $\bar{i}$ is given by
(a) $\theta = \cos^{-1}\left(\frac{1}{\sqrt{3}}\right)$ (b) $\theta = \sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$
(c) $\theta = \cos^{-1}\left(\frac{\sqrt{3}}{2}\right)$ (d) $\theta = \mathrm{sm}^{-1}\left(\frac{\sqrt{3}}{2}\right)$.

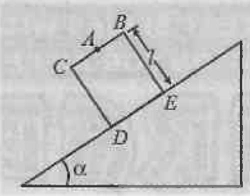
5. Figure shows the v-t graph for two particles P and Q. Which of the following statements regarding their relative motion is true?
Their relative velocity
(a) is zero
(b) is non-zero but constant
(c) continuously decreases
(d) continuously increases.



6. A point traversed half of the distance with a velocity v_0. One portion of remaining part of the distance was covered with velocity v_1 and second part by velocity v_2 with equal time interval t. The mean velocity of the point averaged over the whole time of motion is
(a) $\frac{v_0 + v_1 + v_2}{3}$ (b) $\frac{2v_0 + v_1 + v_2}{3}$
(c) $\frac{v_0 + 2v_1 + 2v_2}{3}$ (d) $\frac{2v_0(v_1 + v_2)}{(2v_0 + v_1 + v_2)}$

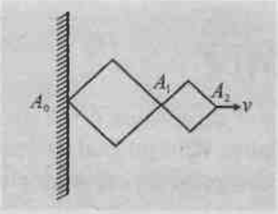
7. The deceleration experienced by a moving motorboat after its engine is cut off, is given by $\frac{dv}{dt} = -kv^3$ where k is constant.
If v_0 is the magnitude of the velocity at cut-off, the magnitude of the velocity at a time t after the cut-off is
(a) $\frac{v_0}{\sqrt{(2v_0^2 kt + 1)}}$ (b) $v_0 e^{-kt}$
(c) $v_0/2$ (d) v_0.

8. A rectangular box is sliding on a smooth inclined plane of inclination α. At $t = 0$, the box starts to move on the inclined plane. A bolt starts to fall from point A. Find the time after which bolt strikes the bottom surface of the box



(a) $\sqrt{\frac{2l}{g\cos\alpha}}$ (b) $\sqrt{\left(\frac{2l}{g\sin\alpha}\right)}$
(c) $\sqrt{\left(\frac{2l}{g}\right)}$ (d) $\sqrt{\left(\frac{l}{g}\right)}$

9. The given thing construction consists of two rhombus with the ratio 3 : 2. The vertex A_2 moves in the horizontal direction with a velocity v. The velocity of A_1 is



(a) 0.6 v (b) 0.7 v (c) 3 v (d) 2 v

10. A boy playing on the roof of a 10 m high building throws a ball with a speed of 10 m/s at an angle of 30° with the horizontal. How far from the throwing point will the ball be at the height of 10 m from the ground?

$$\left[g = 10\ \text{m/s}^2, \sin 30° = \frac{1}{2}, \cos 30° = \frac{\sqrt{3}}{2}\right]$$

(a) 4.33 m (b) 2.60 m (c) 8.66 m (d) 5.20 m.

11. A body of mass m is thrown upwards at an angle θ with the horizontal with velocity v. While rising up the velocity of the mass after t seconds will be

(a) $\sqrt{(v\cos\theta)^2 + (v\sin\theta)^2}$

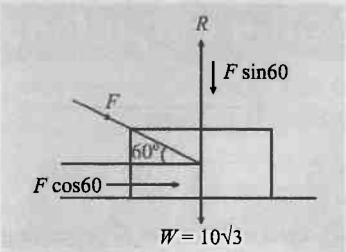
(b) $\sqrt{(v\cos\theta - v\sin\theta)^2 - gt}$

(c) $\sqrt{v^2 + g^2t^2 - (2v\sin\theta)gt}$

(d) $\sqrt{v^2 + g^2t^2 - (2v\cos\theta)gt}$.

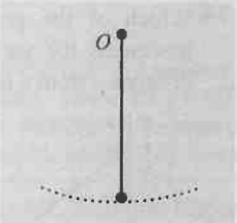
12. What is the maximum value of the force F such that the block shown in the arrangement does not move?

(Given $\mu = \frac{1}{2\sqrt{3}}$)

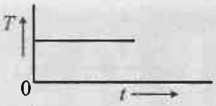


(a) 20 N (b) 10 N (c) 12 N (d) 15 N

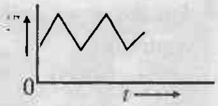
13. A particle of mass m is suspended from a fixed point O by a string of length R. At t = 0, it is displaced from equilibrium position and released. The graph, which shows the variation of the tension T in the string with time t, may be



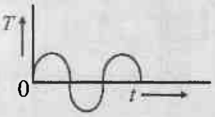
(a)



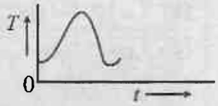
(b)



(c)



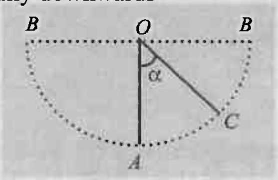
(d)



14. A simple pendulum is vibrating with an angular amplitude of 90° as shown in the given figure. For what value of α, is the acceleration directed?

(i) vertically upwards (ii) horizontally

(iii) vertically downwards



(a) $0°, \cos^{-1}\left(\frac{1}{\sqrt{3}}\right), 90°$ (b) $90°, \cos^{-1}\left(\frac{1}{\sqrt{3}}\right), 0°$

(c) $\cos^{-1}\left(\frac{1}{\sqrt{3}}\right), 0°, 90°$ (d) $\cos^{-1}\left(\frac{1}{\sqrt{3}}\right), 90°, 0°$

15. A force $F = Ay^2 + By + C$ acts on a body in the y-direction. Find the work done by this force during a displacement from $y = -a$ to $y = a$.

(a) $\frac{2Aa^3}{3}$ (b) $\frac{2Aa^3}{3} + 2Ca$

(c) $\frac{2Aa^3}{3} + \frac{Ba^3}{2} + Ca$ (d) none of these.

16. A 1 kg ball moving at 12 ms^{-1} collides head on with 2 kg ball moving with 24 ms^{-1} in opposite direction. What are their velocities after the collision if $e = \frac{2}{3}$?

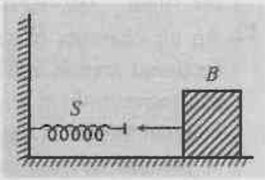
(a) $v_1 = -28$ ms^{-1}, $v_2 = -4$ ms^{-1}

(b) $v_1 = -4$ ms^{-1}, $v_2 = -28$ ms^{-1}

(c) $v_1 = 28$ ms^{-1}, $v_2 = 4$ ms^{-1}

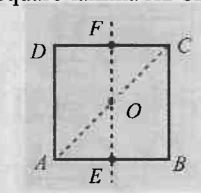
(d) $v_1 = 4$ ms^{-1}, $v_2 = 28$ ms^{-1}

17. A 0.01 kg block collides with a horizontal massless spring of force constant k = 2 N/m. The spring get compressed by 0.4 m. If the coefficient of kinetic friction between the block and the surface is 0.5. The speed of the block at the time of the collision is (g = 10 ms^{-2})



(a) 3 ms^{-1} (b) 1.5 ms^{-1} (c) 6 ms^{-1} (d) 4.5 ms^{-1}.

18. For the given uniform square lamina $ABCD$, whose centre is O,



(a) $I_{AC} = \sqrt{2} I_{EF}$
(b) $I_{AC} = \sqrt{2} I_{EF}$
(c) $I_{AD} = 3 I_{EF}$
(d) $I_{AC} = I_{EF}$

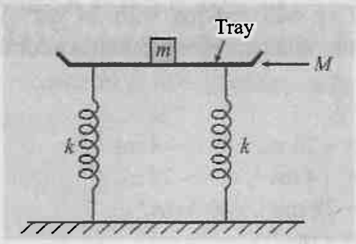
19. A coil having n turns and resistance R Ω is connected with a galvanometer of resistance $4R$ Ω. This combination is moved in time t seconds from a magnetic flux, W_1 weber to W_2 weber. The induced current in the circuit is

(a) $-\dfrac{W_2 - W_1}{5Rnt}$ (b) $-\dfrac{n(W_2 - W_1)}{5Rt}$

(c) $-\dfrac{(W_2 - W_1)}{Rnt}$ (d) $-\dfrac{n(W_2 - W_1)}{Rt}$

20. The moment of inertia of two bodies are I_1 and I_2. Their geometrical shapes and sizes are same, the first made of iron and the second of aluminium, then
(a) $I_1 < I_2$ (b) $I_1 = I_2$
(c) $I_1 > I_2$
(d) relation between I_1 and I_2 depends on the actual shape of the bodies.

21. A tray of mass $M = 10$ kg is supported on two identical springs, each of spring constant k, as shown in figure. When the tray is depressed a little and released, it executes simple harmonic motion of period 1.5 s. When a block mass m is placed on the tray, the period of oscillation becomes 3.0 s. The value of m is



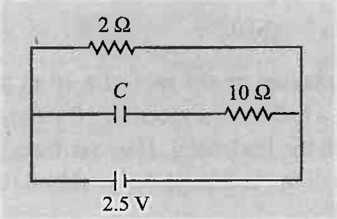
(a) 10 kg (b) 20 kg (c) 30 kg (d) 40 kg

22. An air chamber of volume V has a neck of cross-sectional area a into which a light ball of mass m can move without friction. The diameter of the ball is equal to that of the neck of the chamber. The ball is pressed down a little and released. If the bulk modulus of air is B, the time period of the resulting oscillation of the ball is given by

(a) $T = 2\pi\sqrt{\dfrac{Ba^2}{mV}}$ (b) $T = 2\pi\sqrt{\dfrac{BV}{ma^2}}$

(c) $T = 2\pi\sqrt{\dfrac{mB}{Va^2}}$ (d) $T = 2\pi\sqrt{\dfrac{mV}{Ba^2}}$

23. A capacitor of capacitance $C = 2$ μF is connected as shown in figure. If the internal resistance of the cell is 0.5 Ω, the charge on the capacitor plates is



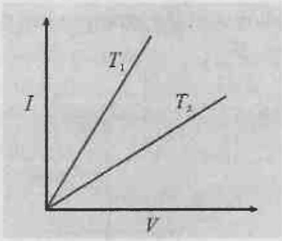
(a) zero (b) 2 μC (c) 4 μC (d) 6 μC.

24. A charge $+q$ is fixed at each of the points $x = x_0$, $x = 3x_0$, $x = 5x_0$ ... upto infinity and a charge $-q$ is fixed at each of the points $x = 2x_0$, $x = 4x_0$, $x = 6x_0$ ... upto infinity. Here x_0 is a positive constant. The potential at the origin of this system of charges is

(a) zero (b) $\dfrac{q}{4\pi\varepsilon_0 x_0 \ln(2)}$

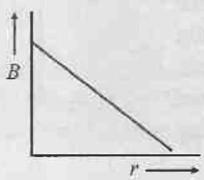
(c) infinity (d) $\dfrac{q\ln(2)}{4\pi\varepsilon_0 x_0}$.

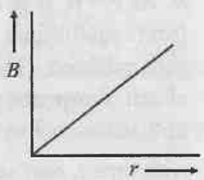
25. The current-voltage (I - V) graphs for a given metallic wire at two different temperatures T_1 and T_2 are shown in figure. It follows from the graphs that

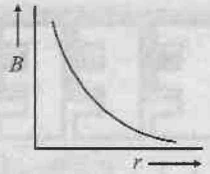


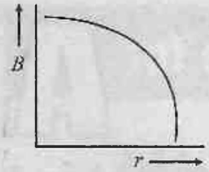
(a) $T_1 > T_2$ (b) $T_1 < T_2$
(c) $T_1 = T_2$
(d) T_1 is greater or less than T_2 depending on whether the resistance R of the wire is greater or less than the ratio V/I

26. Which of the graphs shown in figure correctly represents the variation of magnetic field B with distance r from a long current carrying conductor?

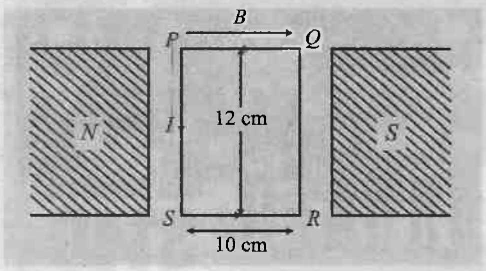
(a) 

(b) 

(c) 

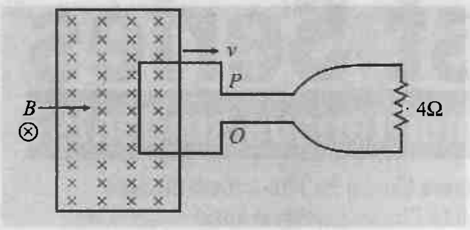
(d) 

27. A rectangular coil of 50 turns carries a current of 2.0 A and is placed in a magnetic field B of 0.25 T, as shown in figure. What is the magnitude of torque acting on the coil?



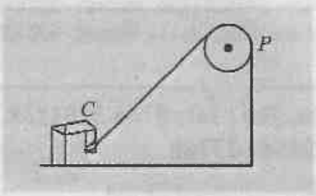
(a) 0.1 Nm (b) 0.2 Nm
(c) 0.3 Nm (d) 0.4 Nm

28. A square metal wire loop of side 10 cm and resistance 1 Ω is moved with a constant velocity v in a uniform magnetic field B = 2 T, as shown in figure. The loop is connected to 4 Ω resistor. What should be the speed v of the loop as to have a steady current of 1 mA in the loop?



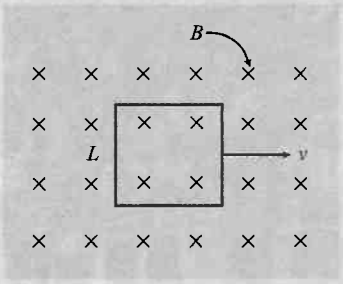
(a) 1 cm s^{-1} (b) 2 cm s^{-1}
(c) 3 cm s^{-1} (d) 4 cm s^{-1}

29. One end of a massless rope, which passes over a massless and frictionless pulley P is tied to a hook C while the other end is free. Maximum tension that the rope can bear is 960 N. With what value of maximum safe acceleration (in ms^{-2}) can a man of 60 kg climb on the rope?



(a) 16 (b) 6 (c) 4 (d) 8.

30. A conducting square loop of side L and resistance R moves in its plane with a uniform velocity v perpendicular to one of its sides. A magnetic field B, constant in space and time, pointing perpendicular and into the plane of the loop exists everywhere as shown in figure. The current induced in the loop is



(a) BLv/R clockwise (b) BLv/R anticlockwise
(c) $2BLv/R$ anticlockwise (d) zero

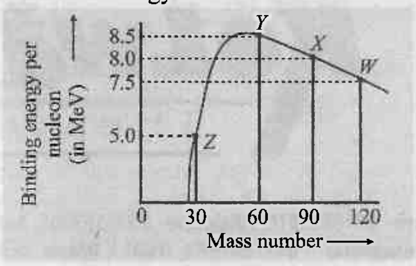
31. In a Young's double slit experiment the intensity at a point where the path difference is $\frac{\lambda}{6}$ (λ being the wavelength of light used) is I. If I_0 denotes the maximum intensity, $\frac{I}{I_0}$ is equal to

(a) $\frac{3}{4}$ (b) $\frac{1}{\sqrt{2}}$ (c) $\frac{\sqrt{3}}{2}$ (d) $\frac{1}{2}$

32. An X-ray tube produces a continuous spectrum of radiation with its short-wavelength end at 0.33 Å. What is the maximum energy of a photon in the radiation? Planck's constant = 6.6 × 10^{-34} Js.

(a) 35 keV (b) 37.5 keV
(c) 40 keV (d) 42.5 keV

33. Binding energy per nucleon versus mass number curve for nuclei is shown in figure. W, X, Y and Z are four nuclei indicated on the curve. The process that would release energy is



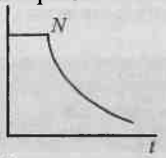
(a) $Y \rightarrow 2Z$ (b) $W \rightarrow X + Z$
(c) $W \rightarrow 2Y$ (d) $X \rightarrow Y + Z$

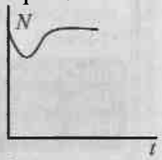
34. A freshly prepared radioactive source of half life 2 hours emits radiation of intensity which is 64 times the permissible safe level. The minimum time after

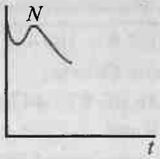
which it would be possible to work safely with the source is

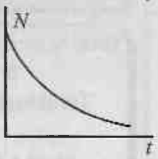
(a) 6 hours (b) 12 hours
(c) 24 hours (d) 128 hours

35. A radioactive sample consists of two distinct species having equal number of atoms initially. The mean life time of one species is τ and that or the other is 5τ. The decay products in both cases are stable. A plot is made of the total number of radioactive nuclei as a function of time. Which of the following figures best represents the form of this plot?

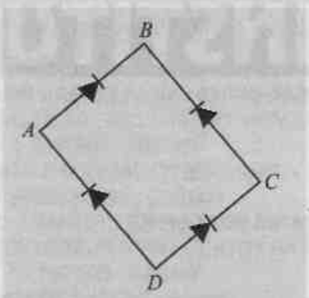
(a) 

(b) 

(c) 

(d) 

36. In the adjoining figure, the input is across the terminals A and C and the output is across B and D. Then the output is



(a) zero (b) the same as the input
(c) full wave rectified (d) half wave rectified

37. Consider a two particle system with particles having massess m_1 and m_2. If the first particle is pushed towards the centre of mass through a distance d, by what distance should the second particle be moved, so as to keep the centre of mass at the same position?

(a) $\frac{m_1}{m_2}d$ (b) d
(c) $\frac{m_2}{m_1}d$ (d) $\frac{m_1}{m_2+m_1}d$

38. The jaws of a vernier calliper touch the inner wall of calorimeter without any undue pressure. The position zero of vernier scale on the main scale reads 4.32 cm. The 5th of vernier scale division is coinciding with any main scale division. Vernier constant of calliper is 0.01 cm. Find actual internal diameter calorimeter, when it is observed that the zero of vernier scale lies on the left of zero of main scale.

(a) 4.37 cm (b) 4.36 cm
(c) 4.42 cm (d) 4.32 cm

39. The thin metallic strip of vernier calliper moves downward from top to bottom in such a way that it just touches the surface of beaker. Main scale reading of calliper is 8.6 cm, whereas its vernier constant is 0.1 mm. The 4th of vernier scale division is coinciding with any main scale division. The actual depth of beaker in mm is (when zero of vernier coincides with zero of main scale)

(a) 8.64 cm (b) 8.62 cm
(c) 8.63 cm (d) 8.13 cm

40. A balance which has arms of equal length and pans of equal weight is called a

(a) sensitive balance (b) inertial balance
(c) true balance (d) beam balance

SOLUTIONS

1. (c) : $\frac{eV}{T}=\frac{W}{T}=\frac{PV}{T}=R$

and $\frac{R}{N_A}=$ Boltzmann constant,

2. (a) : $[\tan\theta]=\frac{[rg]}{[v^2]}=\frac{L(LT^{-2})}{(LT^{-1})^2}=1=[M^0L^0T^0]$

Hence formula is dimensionally correct. But the relation is not correct because of (i) and (ii).

3. (a) : $X=M^aL^b/T^c$;

$$\frac{\Delta X}{X}\times 100=\left(\frac{a\Delta M}{M}+\frac{b\Delta L}{L}+\frac{c\Delta T}{T}\right)\times 100$$

$=(a\alpha+b\beta+c\gamma)\ \%$

4. (a) : $\cos\theta=\frac{(\bar{i}+\bar{j}+\bar{k})\cdot\bar{i}}{(\bar{i}^2+\bar{j}^2+\bar{k}^2)^{1/2}\times(\bar{i}^2)^{1/2}}$

$$=\frac{\bar{i}\cdot\bar{i}+\bar{j}\cdot\bar{i}+\bar{k}\cdot\bar{i}}{(1+1+1)^{1/2}\times 1}=\frac{1+0+0}{\sqrt{3}}=\frac{1}{\sqrt{3}}$$

$(\because \bar{j}\cdot\bar{i}=\bar{k}\cdot\bar{i}=0 \text{ and } \bar{i}\cdot\bar{i}=1)$

5. (d) : The difference in velocities is increasing with time as both of them have constant but different accelerations.

6. (d) : Let the total distance be d.

Then for first half distance, time $=\frac{d}{2v_0}$,

next distance, $=v_1t$

and last part of distance, $= v_2 t$

$\therefore \quad v_1 t + v_2 t = \dfrac{d}{2} \quad$ or $t = \dfrac{d}{2(v_1 + v_2)}$

Now, average speed

$$v = \frac{d}{\dfrac{d}{2v_0} + \dfrac{d}{2(v_1+v_2)} + \dfrac{d}{2(v_1+v_2)}} = \frac{2v_0(v_1+v_2)}{(v_1+v_2)+2v_0}$$

7. (a) : $\dfrac{dv}{dt} = -kv^3$

or $\dfrac{dv}{v^3} = -k\,dt$

Intergrating we get $-\dfrac{1}{2v^2} = -kt + c$ ...(i)

At $t = 0,\ v = v_0$

$\therefore \quad \dfrac{-1}{2v_0^2} = c$

Putting in (i), we get

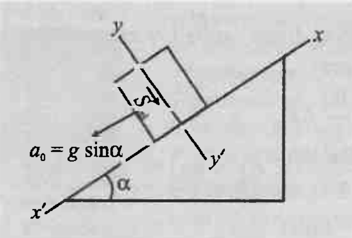
$-\dfrac{1}{2v^2} = -kt - \dfrac{1}{2v_0^2}$

or $\left[\dfrac{1}{2v_0^2} + kt\right] = \dfrac{1}{2v^2}$ or $[1 + 2v_0^2 kt] = \dfrac{v_0^2}{v^2}$

or $v^2 = \dfrac{v_0^2}{1 + 2v_0^2 kt}$ or $v = \dfrac{v_0}{\sqrt{1 + 2v_0^2 kt}}$

8. (a) : Actual acceleration of bolt

$\vec{a}_1 = -g\sin\alpha\,\vec{i} - g\cos\alpha\,\vec{j}$



$\vec{a}_2$ = actual acceleration of box $= -g\sin\alpha\ \vec{i}$

$\therefore \quad \vec{S}_{rel} = -l\,\vec{j}\ ;\ \vec{u}_{rel} = 0$

$S_{rel} = u_{rel}t + \dfrac{1}{2}a_{rel}t^2$

$\Rightarrow -l = 0 + \dfrac{1}{2}(-g\cos\alpha)t^2 \quad \Rightarrow \quad l = \dfrac{gt^2\cos\alpha}{2}$

$\therefore \quad t = \sqrt{\left(\dfrac{2l}{g\cos\alpha}\right)}$

9. (a) : $v_{A_0} = 0,\quad \dfrac{l_1}{l_2} = \dfrac{3}{2}$

$\therefore \quad \dfrac{v_{A_1}}{v_{A_2}} = \dfrac{3}{3+2} = \dfrac{3}{5} \qquad \therefore\ v_{A_1} = 3k,\ v_{A_2} = 5k$

But $\quad 5k = v$

$\therefore \quad k = \dfrac{v}{5} \qquad \therefore\ v_{A_1} = 3 \times \dfrac{v}{5} = 0.6v$

10. (c) : $R = \dfrac{u^2\sin 2\theta}{g} = \dfrac{10\times 10\times \sin 60^\circ}{10} = 5\sqrt{3} = 8.66$ m

11. (c) : Instantaneous velocity of rising mass after t sec will be $v_1 = \sqrt{v_x^2 + v_y^2}$

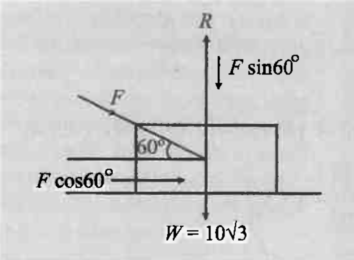
where $v_x = v\cos\theta$ = Horizontal component of velocity

$v_y = v\sin\theta - gt$ = Vertical component of velocity

$v_1 = \sqrt{(v\cos\theta)^2 + (v\sin\theta - gt)^2}$

$v_1 = \sqrt{(v^2 + g^2t^2 - 2v\sin\theta\, gt)}$

12. (a) : $f = \mu R$

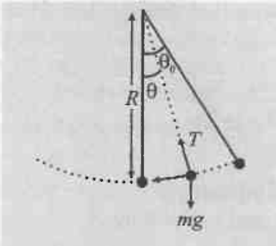


$F\cos 60 = \mu(W + F\sin 60)$

By substituting $\mu = \dfrac{1}{2\sqrt{3}}$ and $W = 10\sqrt{3}$

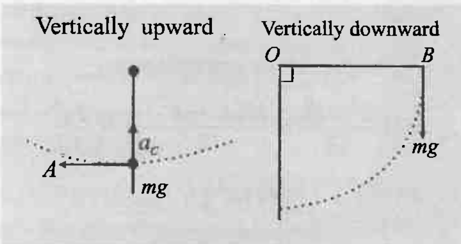
$F = 20$ N

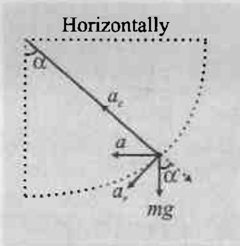
13. (d) : $T - mg\cos\theta = \dfrac{mv^2}{R}$ ...(i)



At equilibrium tension should be maximum and at the position of maximum amplitude tension is minimum but not zero. Also tension varies non linearly. Option (d) is correct.

14. (a) :





$(T - mg\cos\theta) = \frac{mv^2}{R} = m.a_c$ $v^2 = 2gR\cos\alpha$

$a_c = 2g\cos\alpha$, and $a_t = g\sin\alpha$

$$\tan\alpha = \left(\frac{a_c}{a_t}\right) = 2\cot\alpha$$

∴ $\tan\alpha = \sqrt{2}$, $\cos\alpha = \frac{1}{\sqrt{3}}$

15. (b) : $W = \int F\,dy = \int_{-a}^{+a}(Ay^2 + By + C)\,dy$

$$= \left[\frac{Ay^3}{3} + \frac{By^2}{2} + Cy\right]_{-a}^{+a}$$

$$= \frac{Aa^3}{3} + \frac{Ba^2}{2} + Ca - \left(-\frac{Aa^3}{3} + \frac{Ba^2}{2} - Ca\right)$$

$$= \frac{2Aa^3}{3} + 2Ca$$

16. (a) : According to conservation of momentum

$1 \times 12 + 2(-24) = v_1 + 2v_2$

or $v_1 + 2v_2 = -36$ ...(i)

Also $\frac{2}{3} = \frac{v_2 - v_1}{12 - (-24)}$

or $v_2 - v_1 = 24.$ ...(ii)

Solving (i) and (ii) we get

$v_1 = -28\ ms^{-1}$, and $v_2 = -4\ ms^{-1}$

17. (c) : Here,

$$\frac{1}{2}mv^2 = \frac{1}{2}kx^2 + \mu mg.x$$

$$v^2 = \frac{2 \times (0.4)^2}{0.01} + 2 \times 0.5 \times 10 \times 0.4 = \frac{200 \times 16}{100} + 4 = 36$$

or $v = 6\ ms^{-1}$

18. (d) : By perpendicular axes theorem,

$$I_{EF} = M\frac{a^2 + b^2}{12} = \frac{M(a^2 + a^2)}{12} = M\frac{2a^2}{12}$$

$$I_z = \frac{M(2a^2)}{12} + \frac{M(2a^2)}{12} = \frac{Ma^2}{3}.$$

By perpendicular axes theorem,

$$I_{AC} + I_{BD} = I_z \Rightarrow I_{AC} = \frac{I_z}{2} = \frac{Ma^2}{6}$$

By the same theorem $I_{EF} = \frac{I_z}{2} = \frac{Ma^2}{6}$

∴ $I_{AC} = I_{EF}$

19. (b) : Induced current

$$I = \frac{-n}{R'}\frac{d\psi}{dt} = \frac{-n}{R'}\frac{dW}{dt}$$

$$I = -\frac{1}{(R + 4R)}\frac{n(W_2 - W_1)}{t} = -\frac{n(W_2 - W_1)}{5Rt}$$

20. (c) : Iron is denser than aluminium $I_1 > I_2$.

21. (c) : Here $T_1 = 2\pi\sqrt{\frac{M}{2k}}$ and $T_2 = 2\pi\sqrt{\frac{M+m}{2k}}$

∴ $\frac{T_2}{T_1} = \sqrt{\frac{M+m}{M}}$; or $\frac{3.0}{1.5} = \sqrt{\frac{10+m}{10}}$

which gives $m = 30$ kg. Hence the correct choice is (c).

22. (d) : Let P be the pressure of air in the chamber. When the ball is pressed down a distance x, the volume of air decreases from V to say $V - \Delta V$. Hence the pressure increases from P to $P + \Delta P$. The change in volume is $\Delta V = ax$

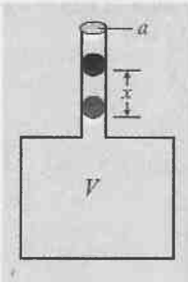
The excess pressure ΔP is related to the bulk modulus B as $\Delta P = -B\frac{\Delta V}{V}$

Now restoring force on ball = excess pressure × cross-sectional area

or $F = -\frac{Ba}{V}\Delta V$

or $F = \frac{-Ba^2x}{v}$ (∵ $\Delta V = ax$) or $F = -kx$

where $k = Ba^2/V$ i.e., $F \propto -x$



Hence the motion of the ball is simple harmonic. If m is the mass of the ball, the time period of the SHM is

$$T = 2\pi\sqrt{\frac{m}{k}} \text{ or } T = 2\pi\sqrt{\frac{mV}{Ba^2}}$$

23. (c) : When the capacitor is fully charged, no current

flows in the 10 Ω resistor. The current in the circuit is

$$I = \frac{2.5}{2+0.5} = 1\text{ A}$$

∴ Potential drop across 2 Ω resistor = 2 Ω × 1A = 2 V
This is also the potential drop across the capacitor plates. Therefore, the charge on capacitor plates is
$Q = CV = 2 \times 10^{-6} \times 2 = 4 \times 10^{-6}$ C = 4 μC
Hence the correct choice is (c).

24. (d) : $V = \frac{1}{4\pi\varepsilon_0}\left\{\frac{q}{x_0} + \frac{q}{3x_0} + \frac{q}{5x_0} + \ldots \text{ upto infinity}\right\}$

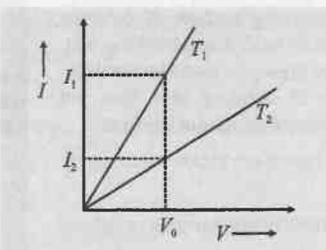
$$+\frac{1}{4\pi\varepsilon_0}\left\{\frac{-q}{2x_0} + \frac{-q}{4x_0} + \frac{-q}{6x_0} + \ldots \text{ upto infinity}\right\}$$

$$= \frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{x_0}\left\{1 - \frac{1}{2} + \frac{1}{3} - \frac{1}{4} + \frac{1}{5} - \frac{1}{6} \ldots \text{ upto infinity}\right\}$$

$$= \frac{q}{4\pi\varepsilon_0 x_0}\ln(1+1) = \frac{q\ln(2)}{4\pi\varepsilon_0 x_0}$$

Hence the correct choice is (d).

25. (b) : It is clear from figure that at a given voltage V_0, the current I_1 in the wire at temperature T_1 is greater than the current I_2 in the wire at temperature T_2. Therefore, the resistance of the wire at temperature T_1 is less than that at temperature T_2. This can happen if T_1 is less than T_2 because the resistance of a wire increases with increase in temperature. Hence the correct choice is (b).



26. (c) : $B \propto 1/r$. Hence the correct graph is (c).

27. (c) : The sides PQ and RS are parallel to the field lines hence the force on each is zero. The force on vertical sides PS and QR is
$f = BIl = 0.25 \times 2.0 \times 0.12 = 0.06$ N
The force f acts on PS in a direction out of the page and on QR into the page, this forming a couple. The total force is
$F = 50 \times 0.06 = 3.0$ N. Therefore, the torque is
$\tau = 3.0\text{ N} \times 0.10\text{ m} = 0.3$ Nm

28. (b) : The emf induced in a wire of length l moving in a field B with speed v perpendicular to the field is given by
$e = Blv = 2 \times 0.1\, v = 0.2\, v$

Current in the circuit is $I = \frac{e}{R} = \frac{0.2v}{4}$.
But $I = 1$ mA $= 10^{-3}$. Therefore,

$$10^{-3} = \frac{0.2v}{4}$$

which gives $v = 2 \times 10^{-2}$ ms^{-1} = 2 cm s^{-1}. Hence the correct choice is (b).

29. (b) : $T - 60g = 60a$
or $960 - (60 \times 10) = 60\,a$
or $60\,a = 360$
or $a = 6$ ms^{-2}

30. (d) : Since the magnetic field is constant in time and space and exists everywhere, there is no change in magnetic flux when the loop is moved in it. Hence no current is induced, which is choice (d).

31. (a) : In Young's double slit experiment intensity at a point is given by

$$I = I_0\cos^2\left(\frac{\phi}{2}\right)$$

where ϕ = phase difference, I_0 = maximum intensity

or $\quad \frac{I}{I_0} = \cos^2\left(\frac{\phi}{2}\right)$ ... (i)

Phase difference $\phi = \frac{2\pi}{\lambda} \times$ path difference

∴ $\phi = \frac{2\pi}{\lambda} \times \frac{\lambda}{6}$ or $\phi = \frac{\pi}{3}$ ... (ii)

Substitute eqn. (ii) in eqn. (i), we get

$$\frac{I}{I_0} = \cos^2\left(\frac{\pi}{6}\right) \text{ or } \frac{I}{I_0} = \frac{3}{4}$$

32. (b) : $E_{max} = h\upsilon_{max} = \frac{hc}{\lambda_{min}} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{0.33 \times 10^{-10}}$
$= 6 \times 10^{-15}$ J = 37.5 ke V

33. (c) : The binding energies of the reactant and the products in the given nuclear reactions are as follows :

Reaction	Reactant	Products
(a) $Y \to 2Z$	60× 8.5 = 510 MeV	2 × 30 × 5.0 = 300 MeV
(b) $W \to X + Z$	120 × 7.5 = 900 MeV	(90 × 8.0 + 30 × 5.0) = 870 MeV
(c) $W \to 2Y$	120 × 7.5 = 900 MeV	2 × 60 × 8.5 = 1020 MeV
(d) $X \to Y + Z$	90 × 8.0 = 720 MeV	(60 × 8.5 + 30 × 5.0) = 660 MeV

The binding energy of the products in reaction (c) is greater than that of the reactant. Hence reaction (c)

releases energy.

34. (b) : Since the half life is 2 hours, the intensity of the radiation falls by a factor of 2 every 2 hours. In 12 hours it will fall by a factor of $(2)^6 = 64$. Thus, in 12 hours the intensity attains the safe level. Hence the correct choice is (b).

35. (d) : For each species, the number of radioactive nuclei decreases exponentially with time. Hence, for both the species taken together, the total number of radioactive nuclei will decrease exponentially with time. This is best represented in plot (d).

36. (c) : The figure is a circuit diagram of a full wave rectifier.

37. (a) : If x_1 and x_2 are the positions of masses m_1 and m_2, the position of the centre of mass is given by

$$x_{cm} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2} \quad \text{..... (i)}$$

If x_1 changes by Δx_1 and x_2 changes by Δx_2, the change in x_{cm} will be

$$\Delta x_{cm} = \frac{m_1 \Delta x_1 + m_2 \Delta x_2}{m_1 + m_2} \quad \text{...(1)}$$

Given $\Delta x_{cm} = 0$ and $\Delta x_1 = d$. Using these values in Eq. (1), we get $m_1 d + m_2 \Delta x_2 = 0$ or

$$\Delta x_2 = -\frac{m_1 d}{m_2}$$

$\therefore$ Distance moved by $m_2 = \frac{m_1 d}{m_2}$, which is choice (a).

38. (c) : $N = 4.32\,\text{cm}$, $n = 5$

V.C = L.C = 0.01 cm

$\therefore$ observed internal diameter of calorimeter

$D_0 = N + n \times \text{V.C}$

$= 4.32 + 5 \times 0.01 = 4.32 + 0.05$

$D_0 = 4.37\,\text{cm}$

Correct internal diameter $D = D_0 + C$

given that $C = 0$ $\therefore$ $D = 4.37\,\text{cm}$

when zero of v.s lies on the left, then

$C = +(n \times L.C) = +0.5$

$D = 4.37 + 0.5 = 4.42\,\text{cm}$

39. (a) : $N = 8.6\,\text{cm}$ $n = 4$

V.C = L.C = 0.01 cm

$\therefore$ Observed diameter of beaker

$= N + n(\text{V.C}) = 8.6 + 4 \times 0.01$

$= 8.6 + 0.04 = 8.64\,\text{cm}$

Here error $C = 0$

$\therefore$ Actual depth of beaker = 8.64 + 0 = 8.64 cm.

40. (c)

NEW PATTERN

Practice Paper IIT-JEE 2008

PAPER - II

PHYSICS

STRAIGHT OBJECTIVE TYPE

This section contains 9 multiple choice questions numbered 1 to 9. Each question has 4 choices (a), (b), (c) and (d), out of which ***ONLY ONE*** *is correct.*

1. The readings of a constant potential difference is noted four times by a student. The student averages these readings but does not take into account the zero error of the voltmeter. The average measurement of the potential difference is

Reading 1	1.176 V
Reading 2	1.178 V
Reading 3	1.177 V
Reading 4	1.176 V

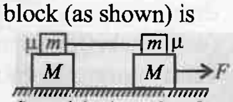
(a) precise and accurate
(b) precise but not accurate
(c) accurate but not precise
(d) not accurate and not precise

2. A metal plate is exposed to light with wavelength λ. It is observed that electrons are ejected from the surface of the plate. When a retarding uniform electric field E is imposed, no electron can move away from the plate farther than a certain distance d. Then the threshold wavelength λ_0 for the material of plate is (e is the electronic charge, h is Planck's constant and c is the speed of light)

(a) $\lambda_0 = \left(\frac{1}{\lambda} - \frac{hc}{eEd}\right)^{-1}$ (b) $\lambda_0 = \left(\frac{1}{\lambda} - \frac{eEd}{hc}\right)^{-1}$

(c) $\lambda_0 = \lambda - \frac{hc}{eEd}$ (d) $\lambda_0 = \lambda - \frac{eEd}{hc}$

3. Four blocks are arranged on a smooth fixed horizontal surface as shown. The masses of upper blocks are m kg and lower blocks are M kg as shown in figure. The coefficient of friction between upper and lower blocks is μ. Both the upper blocks are connected by inextensible light string having initial zero tension. For all four blocks to move with same acceleration, the maximum value of horizontal force F applied to right bottom block (as shown) is

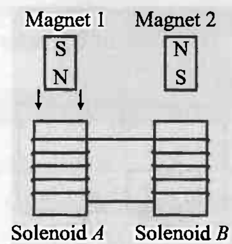


Smooth horizontal surface

(a) $\frac{2\mu mg(m+M)}{2m+M}$ (b) $2\mu g(m+M)$

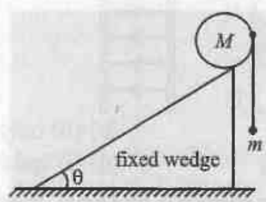
(c) $\frac{2\mu mg(m+M)}{m+2M}$ (d) $\mu g(m+2M)$

4. Two hollow-core solenoids, A and B, are connected by a wire and separated by a large distance, as shown in the diagram. Two bar magnets, 1 and 2, are suspended just above the solenoids. If the magnet 1 is dropped through solenoid A as shown, then the magnet 2 will simultaneously be



(a) attracted by a magnetic force towards solenoid B
(b) repelled by a magnetic force away from solenoid B
(c) repelled by an electric force away from solenoid B
(d) unaffected by solenoid B.

5. A uniform cylinder of mass M lies on a fixed plane inclined at an angle θ with horizontal. A light string is tied to the cylinder's right most point, and a mass m hangs from the string, as shown. Assume that the coefficient of friction between the cylinder and the plane is sufficiently large to prevent slipping. For the cylinder to remain static, the value of mass m is



(a) $\frac{M\cos\theta}{1+\sin\theta}$ (b) $\frac{M\sin\theta}{1+\sin\theta}$

By : **Resonance, Kota** (Rajasthan). For detailed answers of the paper, log on to institute's website www.resonance.ac.in

(c) $\dfrac{M\cos\theta}{1-\sin\theta}$ (d) $\dfrac{M\sin\theta}{1-\sin\theta}$

6. Part of the uranium decay series is shown

$_{92}U^{238} \rightarrow {}_{90}Th^{234} \rightarrow {}_{91}Pa^{234} \rightarrow {}_{92}U^{234} \rightarrow {}_{90}Th^{230} \rightarrow {}_{88}Ra^{226}$

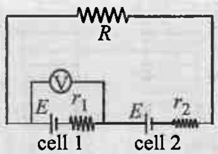
How many pairs of isotopes are there in the above series ?

(a) 1 (b) 2 (c) 3 (d) 0

7. Four uniform wires of the same material are stretched by the same force. The dimensions of wire are as given below. The one which has the minimum elongation has

(a) radius 3 mm, length 3 m
(b) radius 0.5 mm, length 0.5 m
(c) radius 2 mm, length 2 m
(d) radius 3 mm, length 2 m

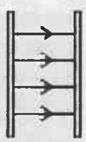
8. In the circuit shown, cells are of equal emf E but of different internal resistances $r_1 = 6\ \Omega$ and $r_2 = 4\ \Omega$. Reading of the ideal voltmeter connected across cell 1 is zero. The value of the external resistance R in ohm is equal to



(a) 2 (b) 2.4 (c) 10 (d) 24

9. Two large oppositely charged insulated plates have a uniform electric field between them as shown. The distance between the plates is increased by a small amount. Which of the following statements is/are correct ?

(i) The electric field strength decreases.
(ii) The electrostatic force of attraction between the plates increases.
(iii) The potential difference between the plates increases.



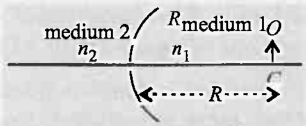
(a) (i) only (b) (ii) only
(c) (iii) only (d) (i) and (iii) only

ASSERTION REASON TYPE

This section contains 4 questions numbered 10 to 13. Each question contains STATEMENT-1 (Assertion) and STATEMENT-2 (Reason). Each question has 4 choices (a), (b), (c) and (d) out of which ONLY ONE is correct.

(a) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(b) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1.
(c) Statement-1 is True, Statement-2 is False.
(d) Statement-1 is False, Statement-2 is True.

10. STATEMENT-1 : A spherical surface of radius of curvature R separates two media of refractive index n_1 and n_2 as shown.



If an object O (a thin small rod) is placed upright on principal axis at a distance R from pole (*i.e*, placed at centre of curvature), then the size of image is same as size of object.

STATEMENT-2 : If a point object is placed at centre of curvature of spherical surface separating two media of different refractive index, then the image is also formed at centre of curvature, *i.e.*, image distance is equal to object distance.

11. STATEMENT-1 : Two concentric conducting spherical shells are charged. The charge on the outer shell is varied keeping the charge on inner shell constant, as a result the electric potential difference between the two shells does not change.

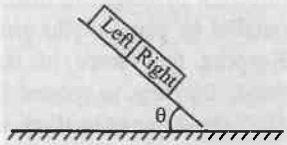
STATEMENT-2 : If charge is changed on an isolated thin conducting spherical shell, the potential at all points inside the shell changes by same amount.

12. STATEMENT-1 : Gas ejected from rocket will never exert thrust on the rocket if the ejected gas and the rocket move in the same direction.

STATEMENT-2 : To exert thrust on rocket in its direction of motion, the ejected gas (w.r.t. rocket) must move opposite to velocity of rocket (w.r.t. ground).

13. STATEMENT-1 : A homogeneous rectangular brick lies at rest on a fixed rough inclined

plane as shown. Then the right half of the brick exerts greater force on the inclined plane as compared to left half of the brick.



STATEMENT-2 : For brick in situation of statement-1 to be at rest, the net moment of all forces about its centre of mass should be zero. Moment of force on brick due to its weight about centre of mass is zero. The moment of force due to friction on brick about its centre of mass has tendency to rotate the brick in clockwise sense. Hence the right half of the brick presses the inclined plane more in comparison to the left half of the brick.

SECTION - III

LINKED COMPREHENSION TYPE

This section contains 2 paragraphs C_{14-16} and C_{17-19}. Based upon each paragraph, 3 multiple choice questions have to be answered. Each question has 4 choices (a), (b), (c) and (d), out of which ONLY ONE is correct.

C_{14-16} : Paragraph for Question Nos. 14 to 16

A uniform and constant magnetic field $B = (20\bar{i} - 30\bar{j} + 50\bar{k})$ tesla exists in space. A charged particle with charge to mass ratio $\left(\frac{q}{m}\right) = \frac{10^3}{19}$ C/kg enters this region at time $t = 0$ with a velocity $\bar{V} = (20\bar{i} + 50\bar{j} + 30\bar{k})$ m/s. Assume that the charged particle always remains in space having the given magnetic field. (Use $\sqrt{2} = 1.4$).

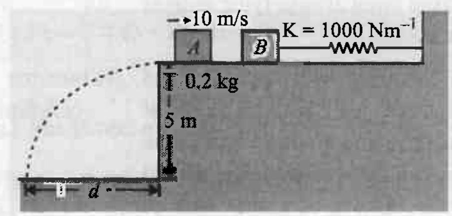
14. During the further motion of the particle in the magnetic field, the angle between the magnetic field $\bar{B}$ and velocity of the particle
(a) remains constant (b) increases
(c) decreases
(d) may increase or decrease.

15. The frequency of the revolution of the particle in cycles per second will be
(a) $\frac{10^3}{\pi\sqrt{19}}$ (b) $\frac{10^4}{\pi\sqrt{38}}$ (c) $\frac{10^4}{\pi\sqrt{19}}$ (d) $\frac{10^4}{2\pi\sqrt{19}}$

16. The pitch of the helical path of the motion of the particle will be
(a) $\frac{\pi}{100}$ m (b) $\frac{\pi}{125}$ m
(c) $\frac{\pi}{215}$ m (d) $\frac{\pi}{250}$ m

C_{17-19} : Paragraph for Question Nos. 17 to 19

Figure shows block A of mass 0.2 kg sliding to the right over a frictionless elevated surface at a speed of 10 m/s. The block undergoes a collision with stationary block B, which is connected to a nondeformed spring of spring constant 1000 Nm^{-1}. The coefficient of restitution between the blocks is 0.5. After the collision, block B oscillates in SHM with a period of 0.2 s, and block A slides off the left end of the elevated surface, landing a distance d from the base of that surface after falling height 5 m. (use $\pi^2 = 10$; $g = 10$ m/s^2). Assume that the spring does not affect the collision.



17. Mass of the block B is
(a) 0.4 kg (b) 0.8 kg (c) 1 kg (d) 1.2 kg

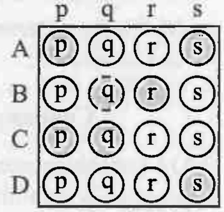
18. Amplitude of the SHM as being executed by block B-spring system, is
(a) $2.5\sqrt{10}$ cm (b) 10 cm
(c) $3\sqrt{10}$ cm (d) $5\sqrt{10}$ cm

19. The distance d will be equal to
(a) 2 m (b) 2.5 m (c) 4 m (d) 6.25 m

SECTION - IV

MATRIX MATCH TYPE

This section contains 3 questions. Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in Column I have to be matched with statements (p, q, r, s) in Column II. The answers to these questions have to be appropriately bubbled as illustrated in the following example. If the correct matches are A-p, A-s, B-q, B-r, C-p, C-q and D-s, then the correctly bubbled 4 × 4 matrix should be as follows



20. Match the statements in Colum I with the results in Column II.

Column - I	Column - II
(A) A thin uniform spherical shell of surface area S has an initial temperature more than its surrounding atmosphere. Then magnitude of rate of change of its temperature with time	(p) is independent of S
(B) A soap bubble initially in equilibrium is given a charge Q, which distributes uniformly over its surface. The centre of the bubble is always fixed. For the duration the bubble having surface area S expands, the magnitude of electric potential at a fixed point always lying outside the bubble	(q) depends on S
(C) A container with open top and filled with ideal liquid is placed at rest on a smooth horizontal table. A small hole of area S is drilled at the bottom of a side wall of container. The magnitude of force exerted by escaping liquid on the container	(r) remains constant
(D) An infinitely long straight current carrying wire lies along the axis of a closed cylindrical surface of total surface area S in space. As the magnitude of current in the wire is continuously increased, the magnitude of the magnetic flux through the surface of this cylinder	(s) decreases with time

21. Match the statements in Column - 1 with the results in Column - II.

Column - I	Column - II
(A) A variable resistor is connected across a non-ideal cell . As the resistance of the variable resistor is continuously increased from zero to a very large value, the electric power consumed by the variable resistor	(p) first increases for some time and then decreases
(B) A circular ring lies in space having uniform and constant magnetic field. Initially the direction of magnetic field is parallel to plane of the ring. Keeping the centre of ring fixed, the ring is rotated by 180° about one of its diameter with constant angular speed. For the duration the ring rotates, the magnitude of induced emf in the ring	(q) first decreases for some time and then increases
(C) A thin rod of length 1 cm lies along principal axis of a convex lens of focal length 5 cm. One end of rod is at a distance 10 cm from optical centre of the lens. The convex lens is moved (without rotation) perpendicular to initial principal axis by 5 mm and brought back to its initial position. The length of the image of the rod	(r) is always constant
(D) A bulb (of negligible inductance) and a capacitor in series are connected across an ideal ac source of constant peak voltage and variable frequency. As frequency of ac source is continuously increased, the brightness of bulb	(s) increases or may increase over some time interval

22. Net force on a system of particles in ground frame is zero. In each situation of column-I a statement is given regarding this system. Match the statements in column-I with the results in column-II.

Column-I	Column-II
(A) Acceleration of centre of mass of system from ground frame	(q) is constant
(B) Net momentum of system from ground frame	(q) is zero
(C) Net momentum of system from frame of centre of mass of system	(r) may be zero
(D) K.E. of system from frame of centre of mass of system	(s) may be constant

Useful data :

Gas Constant, $R = 8.314\ JK^{-1}\ mol^{-1}$

$1\ F = 96500\ C$

Atomic Numbers : H = 1, Li = 3, B = 5, C = 6, N = 7, O = 8, F = 9, Na = 11, P = 15, S = 16, Cl = 17, Ar = 18, K = 19, V = 23, Cr = 24, Mn = 25, Fe = 26, Co = 27, Ni = 28, Cu = 29, Zn = 30, Ge = 32, Br = 35, Ag = 47, I = 53, Xe = 54, Pt = 78, Hg = 80, Pb = 82.

SECTION - I

STRAIGHT OBJECTIVE TYPE

This section contains 9 multiple choice questions numbered 23 to 31. Each question has 4 choices (a), (b), (c) and (d), out of which ONLY ONE is correct.

23. How many mmoles of sucrose should be dissolved in 500 gms of water so as to get a solution which has a difference of 103.57°C between boiling point and freezing point. ($K_f = 1.86$ K kg mol^{-1}, $K_b = 0.52$ K kg mol^{-1})
(a) 500 mmoles (b) 900 mmoles
(c) 750 mmoles (d) 650 mmoles

24. Identify true and false statements
S_1 : XeO_3 is a colourless explosive solid and has a pyramidal molecular structure.
S_2 : XeF_2 is not a better oxidising agent than XeF_4.
S_3 : Xe, Kr and Ne all form clatherate compounds.
S_4 : Fluorine in dilute solution of sodium hydroxide disproportionates in fluoride and hypofluorite.
(a) TFFF (b) TFTF (c) TTTT (d) FTFT

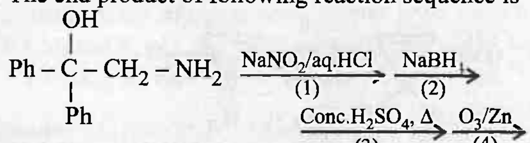
25. At 298 K the standard free energy of formation of $H_2O_{(l)}$ is –257.20 kJ/mole while that of its ionisation into H^+ ion and hydroxyl ions is 80.35 kJ/mole, then the emf of the following cell at 298 K will be (take F = 96500 C]
H_2(g,1 bar) | H^+ (1 M) || OH^- (1 M) | O_2 (g, 1bar)
(a) 0.40 V (b) 0.50 V (c) 1.23 V (d) –0.40 V

26. According to molecular orbital theory, which of the following is correct ?
(a) LUMO level for C_2 molecule is a σ_{2p} orbital
(b) In C_2 molecule both the bonds are π-bonds
(c) In C_2^{2-} ion there is one σ and two π bonds
(d) All the above are correct

27. When a graph is plotted between log x/m and log p, it is straight line with an angle 45° and intercept 0.3010 on y-axis. If initial pressure is 0.3 atm, what will be the amount of gas adsorbed per gm of adsorbent ?
(a) 0.4 (b) 0.6 (c) 0.8 (d) 0.1

28. The green coloured complex $K_2[Cr(CN)_4(NH_3)(NO)]$ is paramagnetic and its paramagnetic moment (spin only) is found to be 1.73 B.M. Which of the following is /are correct about it ?
(a) Hybridisation state of chromium is sp^3d^2 and it cannot show geometrical isomerism
(b) Its IUPAC name is Potassium amminetetracyano nitrosylchromate(II)
(c) In the complex chromium is in (+III) oxidation number.
(d) None of the above is correct

29. The end product of following reaction sequence is

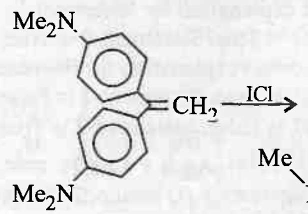


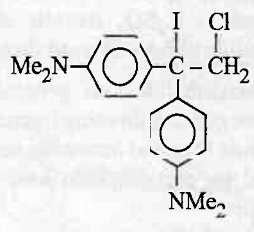
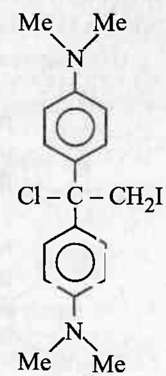
(a) $Ph-\underset{\substack{|\\ Ph}}{C}=O + CH_2=O$

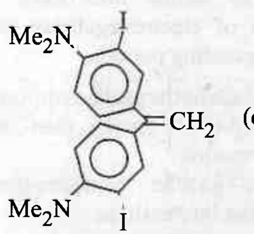
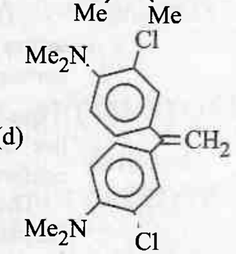
(b) $Ph-\underset{\substack{|\\ CH_3}}{C}=O + PhCH=O$

(c) $PhCH=O$ only (d) $Ph-\overset{\substack{O\\ \|}}{C}-CH_2-Ph$

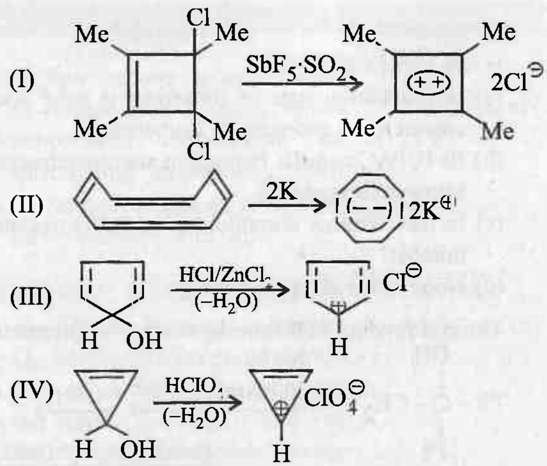
30. The major product formed in the following reaction is



(a)  (b) 

(c)  (d) 

31. Which of the following reactions are feasible (practically possible) ?



(a) I, IV (b) II, III (c) I, II, IV (d) I, II, III

SECTION - II

ASSERTION REASON TYPE

This section contains 4 questions numbered 32 to 35. Each question contains STATEMENT-1(Assertion) and STATEMENT-2 (Reason). Each question has 4 choices (a), (b), (c) and (d) out of which ONLY ONE is correct.

(a) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(b) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(c) Statement-1 is True, Statement-2 is False
(d) Statement-1 is False, Statement-2 is True

32. STATEMENT-1: $Ag_2S + 4\,KCN \overset{O_2}{\rightleftharpoons} 2K\,[Ag(CN)_2] + K_2S$

STATEMENT-2: The reaction is carried out in presence of air or O_2 so that K_2S is oxidised to K_2SO_4 thereby shifting the equilibrium in forward direction.

33. STATEMENT-1: Pseudohalide ions generally are not stronger coordinating ligands than the halide ions and hence the complex formed by pseudohalide ions are of high spin.

STATEMENT-2: The halide ions have higher values of electronegativity in their corresponding periods.

34. STATEMENT-1 In n-butane the gauche conformation lies higher in energy than the anti conformation.

STATEMENT-2 The gauche conformation has eclipsing interactions.

35. STATEMENT-1 The reactivity order for acid catalyzed dehydration of alcohols is $R_3C-OH > R_2CHOH > RCH_2OH$

STATEMENT-2: Acid catalyzed dehydration follows saytzeff (Zaitsev's) rule.

SECTION - III

LINKED COMPREHENSION TYPE

This section contains 2 paragraphs C_{36-38} and C_{39-41}. Based upon each paragraph, 3 multiple choice question have to be answered. Each question has 4 choices (a), (b), (c) and (d), out of which ONLY ONE is correct.

C_{36-38} : Paragraph for Question Nos. 36 to 38

White crystalline solid (A) reacts with H_2 to form a highly associated liquid (B) and a monoatomic, colourless gas (C). The liquid (B) is used for etching glass. Compound (A) undergoes hydrolysis slowly to form (C), (B) and a diatomic gas (D) whose IE is almost similar to that of (C). (B) forms an addition compound with KF to form (E) which is electrolysed in the molten state to form a most reactive gas (F) which combines with (C) in 2:1 ratio to produce (A).

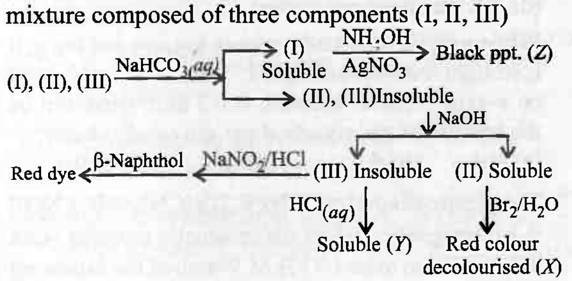
36. The molecular shape, and hybridisation state of central atom in the molecule A is
(a) linear, sp (b) triangular, sp^2
(c) linear, sp^3d (d) V-shape, sp^3

37. The molecule of compound E contains which of the following types of bonds
(a) ionic
(b) ionic and covalent both
(c) ionic, covalent and metallic
(d) ionic, covalent and H-bonds

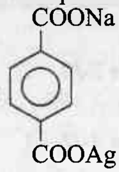
38. According to Molecular Orbital Theory, which of the following is correct about the molecule of D ?
(a) its bond order is 2.0
(b) it has two unpaired electrons in π-bonding M.O.
(c) both the above are correct
(d) none of these is correct

C_{39-41} : Paragraph for Question Nos. 39 to 41

The components of organic mixture can be separated by simple chemical method. Aromatic carboxylic acids are soluble in sodium bicarbonate solution, while the phenols are soluble in NaOH solution. Organic bases (aromatic amines) are soluble in aqueous HCl solution. The separted components are identified by laboratory tests of functional groups. Observe the analysis of following organic mixture composed of three components (I, II, III)

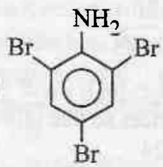


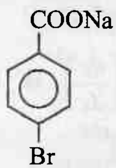
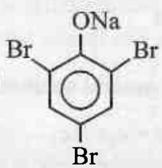
39. The compound Z can be

(a)  (b) 

(c)  (d) 

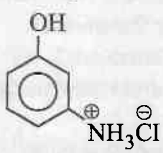
40. The compound X can be

(a)  (b) 

(c)  (d) 

41. The compound Y can be

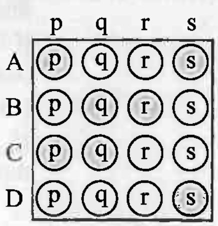
(a)  (b) 

(c)  (d) 

SECTION - IV

MATRIX MATCH TYPE

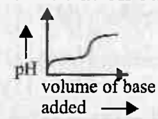
This section contains 3 questions. Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in **Column-I** have to be matched with statements (p, q, r, s) in **Column-II**. The answers to these questions have to be appropriately bubbled as illustrated in the following example. If the correct matches are A-p, A-s, B-q, B-r, C-p, C-q and D-s, then the correctly bubbled 4 × 4 matrix should be as follows :



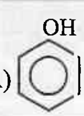
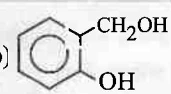
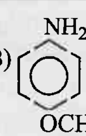
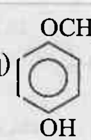
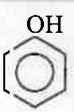
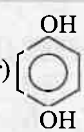
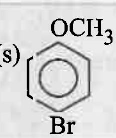
42.

Column-I	Column-II
(A) $(NH_4)_2S_2O_8 + H_2O \rightarrow$	(p) Hydrolysis
(B) $NaBO_2 + H_2O + H_2O_2 \xrightarrow{OH^-}$	(q) One of the product has peroxide linkage
(C) $XeF_4 + H_2O \rightarrow$	(r) Redox Reaction
(D) $HNO_3(50\%) + As_2O_3 + H_2O$ (unbalanced) $\rightarrow$	(s) one of the products is a gas (paramagnetic)

43. For the following matching take the concentrations of the both the solutions being titrated to be equal to 0.1 M, and K_a of $CH_3COOH = 2 \times 10^{-5}$, K_{a_1} of $H_2CO_3 = 10^{-7}$, K_{a_2} of $H_2CO_3 = 10^{-11}$, K_b of $NH_3 = 2 \times 10^{-5}$)

Column-I (Titrations)	**Column-II** (Properties)
(A) $CH_3COOH + NaOH$	(p) Approximate shape of the titration curve will 
(B) $NH_4Cl + NaOH$	(q) Phenolphthalein ($pK_{In} = 9$) can be used for end point detection
(C) $Na_2CO_3 + HCl$ (upto Ist equivalence point)	(r) At equivalence point, $\alpha_{water} < 1.8 \times 10^{-9}$
(D) $HCl + NaOH$	(s) At equivalence point, pH > 7

44. Match following column (I) with column (II)

Column-I (Reactants)	**Column-II** (Products)
(A)  (i) Br_2/CS_2 (ii) $(CH_3)_2SO_4/OH^-$	(p) 
(B)  (i) $NaNO_2/HCl_{(aq)}$ (ii) Δ	(q) 
(C)  (i) $CHBr_3/OH^-$ (ii) H_2O (iii) $NaBH_4$	(r) 
(D)  (i) Br_2/Fe (ii) Mg/ether (iii) O_2 (iv) H_2O	(s) 

SECTION - I

STRAIGHT OBJECTIVE TYPE

This section contains 9 multiple choice questions numbered 45 to 53. Each question has 4 choices (a), (b), (c) and (d), out of which ONLY ONE is correct.

45. Let $y = f(x)$ be a cubic polynomial function which attain its local maximum at $x = 3$ and point of inflection is at $x = 7$, then
(a) local minimum is at $x = 11$
(b) local minimum is at $x = \sqrt{21}$
(c) local minimum is at $x = -1$
(d) data insufficient

46. Equation of circle of minimum radius which touches both the parabolas $y = x^2 + 2x + 4$ and $x = y^2 + 2y + 4$ is
(a) $4x^2 + 4y^2 - 11x - 11y - 13 = 0$
(b) $2x^2 + 2y^2 - 11x - 11y - 13 = 0$
(c) $3x^2 + 3y^2 - 11x - 11y - 13 = 0$
(d) $x^2 + y^2 - 11x - 11y - 13 = 0$

47. If $y = f(x)$ is differentiable at $x = a$ and $y = g(x)$ is continuous but not differentiable at $x = a$, $g'(a^+)$ and $g'(a^-)$ are finite, then which of the following is incorrect ?
(a) $y = f(x)\ g(x)$ is not differentiable at $x = a$ if $f(a) \neq 0$
(b) $y = f(x)\ g(x)$ is differentiable at $x = a$ if $f(a) = 0$
(c) $y = f(x)\ g(x)$ is not differentiable at $x = a$ if $f(a) = 0$
(d) $y = f(x)\ g(x)$ is continuous at $x = a$

48. Area bounded by $y = f^{-1}(x), x = 0, y = \frac{\pi}{6}$ and $y = \frac{5\pi}{6}$ where $f(x) = x + \sin x$, is
(a) $3\sqrt{3} + \frac{\pi^2}{3}$ (b) $2\sqrt{3} + \frac{\pi^2}{3}$
(c) $\sqrt{3} + \frac{\pi^2}{3}$ (d) $\frac{\pi^2}{3} - \sqrt{3}$

49. Let $I_1 = \int_{\pi/6}^{\pi/3} \frac{\sin x}{x} dx, I_2 = \int_{\pi/6}^{\pi/3} \frac{\sin(\sin x)}{\sin x} dx,$
$I_3 = \int_{\pi/6}^{\pi/3} \frac{\sin(\tan x)}{\tan x} dx,$ then
(a) $I_1 < I_2 < I_3$ (b) $I_2 < I_1 < I_3$
(c) $I_3 < I_1 < I_2$ (d) $I_3 < I_2 < I_1$

50. If $\vec{a}, \vec{b}$ are non-zero vectors such that $|\vec{a} + \vec{b}| = |\vec{a} - 2\vec{b}|$ then
(a) $\vec{a} \cdot \vec{b} = 2|\vec{b}|^2$ (b) $\vec{a} \cdot \vec{b} = |\vec{b}|^2$
(c) least value of $\vec{a} \cdot \vec{b} + \frac{4}{|\vec{b}|^2 + 2}$ is $2\sqrt{2}$
(d) least value of $\vec{a} \cdot \vec{b} + \frac{4}{|\vec{b}|^2 + 2}$ is $2\sqrt{2} - 1$

51. If a unit vector $\vec{a}$ in the plane of $\vec{b} = 2\vec{i} + \vec{j}$ and $\vec{c} = \vec{i} - \vec{j} + \vec{k}$ is such that $\vec{a} \times \vec{b} = \vec{a} \times \vec{d}$ where $\vec{d} = \vec{j} + 2\vec{k}$, then $\vec{a}$ is
(a) $\frac{\vec{i} + \vec{j} + \vec{k}}{\sqrt{3}}$ (b) $\frac{\vec{i} - \vec{j} + \vec{k}}{\sqrt{3}}$
(c) $\frac{2\vec{i} + \vec{j}}{\sqrt{5}}$ (d) $\frac{2\vec{i} - \vec{j}}{\sqrt{5}}$

52. If $A = [a_{ij}]_{3 \times 3}$, $B = [b_{ij}]_{2 \times 2}$, $C = [c_{ij}]_{3 \times 3}$ are three matrices so that $|A| = 3$, $|B| = -2$, $|C| = 4$, then $|ABC|$ is
(a) 24 (b) –24
(c) 0 (d) not defined

53. The general solution of $y \cdot \frac{d^2y}{dx^2} = \left(\frac{dy}{dx}\right)^2$ is
(a) $y = c_1x + c_2$ (b) $y = c_1e^{c_2x}$
(c) $y = c_1x + c_2e^x$ (d) $y = e^{c_1x} + e^{c_2x}$

SECTION - II

ASSERTION - REASON TYPE

This section contains 4 questions numbered 54 to 57. Each questions contain STATEMENT-1 (Assertion) and STATEMENT-2 (Reason). Each question has 4 choice (a), (b), (c) an (d) out of whic ONLY ONE is correct.

(a) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(b) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(c) Statement-1 is True, Statement-2 is False
(d) Statement-1 is False, Statement-2 is True

54. STATEMENT-1 : Let $L_1 = 0$ and $L_2 = 0$ are two non perpendicular intersecting straight lines in two dimensional plane and if for $\lambda = 1$, $L_1 + \lambda L_2 = 0$ gives line passing through acute angular region between the lines then for $\lambda = -4$ $L_1 + \lambda L_2 = 0$ gives line passing through obtuse angular region.

STATEMENT-2 : Points (x_1, y_1) and (x_2, y_2) are on the same / opposite sides of a line $ax + by + c = 0$ if and only if $ax_1 + by_1 + c$ and $ax_2 + by_2 + c$ are of

same/opposite signs respectively.

55. STATEMENT-1 : Roots of $ax^2 + bx + c = 0$ are real if $b^2 - 4ac \geq 0$.

STATEMENT-2 : Set of all real numbers and set of all imaginary numbers are subsets of set of all complex numbers.

56. STATEMENT-1 : In a ΔABC if $\cos A \cos B + \sin A \sin B \sin C = 1$, then ABC is right angle triangle.

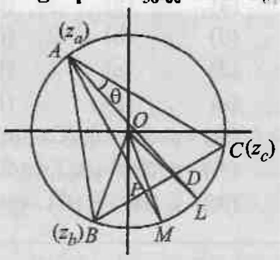
STATEMENT-2 : If $k \leq p + qr < p + q < k$, then $k = p + qr = p + q = k$ and $r = 1$.

57. STATEMENT-1 : Let $f: R \to R$ be thrice differentiable non constant function, then between two consecutive real roots of $f'''(x) = 0$, there are atmost four real roots of $f(x) = 0$.

STATEMENT-2 : If $f(x)$ is differentiable in $[a, b]$, then there exist atleast one $c \in (a, b)$ for which $f'(c) = \dfrac{f(b) - f(a)}{b - a}$.

SECTION - III
LINKED COMPREHENSION TYPE

This section contains 2 paragraphs $C_{58\text{-}60}$ and $C_{61\text{-}63}$. Based upon each paragraph, 3 multiple choice questions have to be answered. Each question has 4 choices (a), (b), (c) and (d), out of which ONLY ONE is correct.



$C_{58\text{-}60}$: Paragraph for Question Nos. 58 to 60

In the figure $|z| = r$ is circumcircle of ΔABC. D, E and F are the middle points of the sides BC, CA and AB respectively, AD produced to meet the circle at L. If $\angle CAD = \theta$, $AD = x$, $BD = y$ and altitude of ΔABC from A meet the circle $|z| = r$ at M, z_a, z_b and z_c are affixes of vertices A, B and C respectively. Then

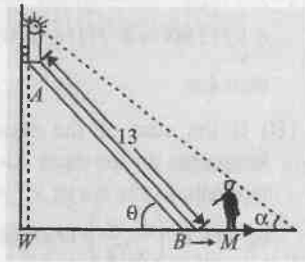
58. Area of the ΔABC is equal to
(a) $xy\cos(\theta + C)$ (b) $(x + y)\sin\theta$
(c) $xy\sin(\theta + C)$ (d) $\frac{1}{2}xy\sin(\theta + C)$

59. Affix of M is
(a) $2z_b e^{i2B}$ (b) $z_b e^{i(\pi - 2B)}$ (c) $z_b e^{iB}$ (d) $2z_b e^{iB}$

60. Affix of L is
(a) $z_b e^{i(2A - 2\theta)}$ (b) $2z_b e^{i(2A - 2\theta)}$
(c) $z_b e^{i(A - \theta)}$ (d) $2z_b e^{i(A - \theta)}$

$C_{61\text{-}63}$: Paragraph for Question Nos. 61 to 63

A lamp post of length 10 meter placed at the end A of a ladder AB of length 13 meter, which is leaning against a vertical wall as shown in figure and its base slides away from the wall. At the instant base B is 12 m from the vertical wall, the base B is moving at the rate of 5 m/sec. A man (M) of height 1.5 meter standing at a distance 15 m from the vertical wall, then answer the following question.



61. Rate at which θ decreases, when the base B is 12 m from the vertical wall, is
(a) 1 rad/sec (b) 2 rad/sec
(c) 5 rad/sec (d) $\frac{1}{2}$ rad/sec

62. Rate at which length of shadow of the man increases, when the base B is 12 m from the vertical wall, is
(a) 15 m/sec (b) $\frac{40}{27}$ m/sec
(c) $\frac{15}{2}$ m/sec (d) 5 m/sec

63. Rate at which α decreases, when the base B is 12 m from the vertical wall, is
(a) $\frac{72}{35}$ rad/sec (b) $\frac{80}{181}$ rad/sec
(c) $\frac{36}{5}$ rad/sec (d) 20 rad/sec

SECTION - IV
MATRIX-MATCH TYPE

This section contains 3 questions. Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in Column I have to be matched with statements (p, q, r, s) in Column II. The answers to these questions have to be appropriately bubbled as illustrated in the following example. If the correct matches are A-p, A-s, B-q, B-r, C-p, C-q and D-s, then the correctly bubbled 4 × 4 matrix should be as follows :

	p	q	r	s
A	(p)	(q)	(r)	(s)
B	(p)	(q)	(r)	(s)
C	(p)	(q)	(r)	(s)
D	(p)	(q)	(r)	(s)

64.

Column I	Column II
(A) If $f(x)$ is a quadratic expression in x and $6\int_0^1 f(x)dx = k\ f(1) + f(0) + 4f(1/2)$ then k is	(p) 1
(B) If the sum of the squares of the intercepts on the axes cut off by the tangents to the curve $x^{1/3} + y^{1/3} = a^{1/3}$ $(a > 0)$ at $\left(\frac{a}{8}, \frac{a}{8}\right)$ is 2, then a is	(q) 4
(C) The distance of the point on $y = x^4 + 3x^2 + 2x$ which is nearest to the line $y = 2x - 1$ is r, then $\sqrt{5}r$ is	(r) 3
(D) If $f(x) = -2\,\lvert\sin x\rvert + ae^{\lvert x\rvert} + 5\,\lvert\tan x\rvert^3$ is differentiable at $x = 0$, then a is	(s) 2

65.

Column I	Column II
(A) Number of integral value of b for which tangent parallel to line $y = x + 1$ can be drawn to hyperbola $\frac{x^2}{5} - \frac{y^2}{b^2} = 1$	(p) 4
(B) $x^2 + y^2 + 2xy + 2x + 2y + \lambda = 0$ does not represent a pair of real straight line if $\lambda =$	(q) 5
(C) Number of solution of $\tan 2x = \tan 6x$ in $(0, 3\pi)$ is	(r) 6
(D) If in the expansion of $(2^{1/3} + 3^{-1/3})^n$ the ratio of 7th term from begining to the 7th term from end is 1 : 6, then n is	(s) 9

66.

Column I	Column II
(A) Minimum value of $\frac{x^3 + x + 2}{x}$, $x \in (0, \infty)$ is	(p) 6
(B) Number of real solutions of $\lvert x\rvert + 2\sqrt{5 - 4x - x^2} = 16$ is	(q) 1
(C) If $A_r = \begin{pmatrix} r & r-1 \\ r-1 & r \end{pmatrix}$ where r is a natural number $\lvert A_1\rvert + \lvert A_2\rvert + \lvert A_3\rvert + \ldots + \lvert A_{2006}\rvert = k\,(2006)^2$, then k is equal to	(r) 0
(D) The lengths of two opposite edges AB and CD of a tetrahedron $ABCD$ are a and b. Shortest distance and angle between AB and CD are equal to d and θ respectively. If the volume V of the tetrahedron is $\frac{1}{p}\,abd\sin\theta$, then p is equal to	(s) 4

ANSWERS

1. (b) 2. (b) 3. (a) 4. (a) 5. (d)
6. (b) 7. (d) 8. (a) 9. (c) 10. (d)
11. (a) 12. (d) 13. (a) 14. (a) 15. (b)
16. (d) 17. (c) 18. (a) 19. (b)
20. (A) - p,s; (B) - p,r; (C) - q,s; (D) p,r
21. (A) - p,s; (B) - q,s; (C) - p,s; (D) s
22. (A) - p,q; (B) - p,r; (C) - p,q; (D) r,s
23. (c) 24. (a) 25. (b) 26. (d) 27. (b)
28. (d) 29. (c) 30. (b) 31. (c) 32. (a)
33. (d) 34. (c) 35. (b) 36. (c) 37. (d)
38. (a) 39. (b) 40. (d) 41. (a)
42. (A) - p,q; (B) - p,q; (C) - p,r,s; (D) - r,s
43. (A) - p,q,r,s; (B) - p,r,s; (C) - q,r,s; (D) q,r
44. (A) - s; (B) - q; (C) - p; (D) - r
45. (a) 46. (a) 47. (c) 48. (c) 49. (c)
50. (d) 51. (b) 52. (d) 53. (b) 54. (a)
55. (d) 56. (a) 57. (b) 58. (c) 59. (b)
60. (a) 61. (a) 62. (b) 63. (b)
64. (A) - p; (B) - q; (C) - p; (D) - s
65. (A) - p; (B) - p,q,r,s; (C) - q; (D) - s
66. (A) - s; (B) - r; (C) - q; (D) - p

For Paper - I refer Chemistry Today, March issue.

Breathing Dirty Air May Lower Kid's IQ

Kids who live in neighbourhoods with heavy traffic pollution have lower IQ and score worse on other tests of intelligence and memory than children who breathe cleaner air, a new study shows.

Train Your Brain

This exercise will give your brain the workout it needs.

Canadian Physics Olympiad Problems

DATA

Speed of light	$c = 3.00 \times 10^8$ m/s
Gravitational constant	$G = 6.67 \times 10^{-11}$ N·m²/kg²
Radius of Earth	$R_E = 6.38 \times 10^3$ km
Mass of Earth	$M_E = 6.0 \times 10^{24}$ kg
Mass of Sun	$M_S = 2.0 \times 10^{30}$ kg
Radius of Earth's orbit	$R_{ES} = 1.50 \times 10^8$ km
Acceleration due to gravity	$g = 9.80$ m/s²
Fundamental charge	$e = 1.60 \times 10^{-19}$ C
Mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
Mass of proton	$m_p = 1.673 \times 10^{-27}$ kg
Planck's constant	$h = 6.63 \times 10^{-34}$ Js
Coulomb's constant	$1/4\pi\varepsilon_0 = 8.99 \times 10^{-9}$ Jm/C²
Speed of sound in air	$v_s = 343$ m/s
Energy conversion	$1 \text{ eV} = 1.6 \times 10^{-19}$ J

MULTIPLE CHOICE QUESTION WITH ONE CORRECT OPTION

1. A parallel-plate capacitor holds charge q and is not connected to anything. The distance between the plates is now increased. The electrical energy stored on the capacitor
(a) decreases (b) remains the same
(c) increases
(d) can do any of the above, depending on how the capacitance changes.

2. When an electromagnetic wave goes from one medium to another, it undergoes a change in
(a) amplitude only
(b) both speed and wavelength
(c) speed only (d) wavelength only.

3. Two identical rooms in a perfectly insulated house are connected by an open doorway. The temperature in the two rooms are maintained at different values. The room which contains more air molecules is
(a) the one with the higher temperature
(b) the one with the lower temperature
(c) the one with the higher pressure
(d) neither, since both have the same volume.

4. Three airplanes A, B and C, each release an object from the same altitude and with the same initial speed v_0 with respect to the ground. At the moment their object is released, A is flying horizontally, B is flying upward at an angle θ with respect to the horizontal, and C is flying at the same angle θ as B but downward with respect to the horizontal. Assuming the ground to be horizontal and neglecting any aerodynamical effect, the speeds v at which the three objects will hit the ground satisfy
(a) $v_A = v_B < v_C$ (b) $v_A > v_B = v_C$
(c) $v_A < v_B < v_C$ (d) $v_A = v_B = v_C$.

5. Two identical conducting spheres, A and B, carry equal electric charge. They are separated by a distance much larger than their diameter and exert an electrostatic force F on each other. A third identical conducting sphere C is initially uncharged and far away from A and B. Sphere C is then brought briefly into contact with sphere A, then with sphere B, and finally removed far away. The electrostatic force between A and B is now
(a) $3F/8$ (b) $F/2$ (c) $F/4$ (d) $F/16$.

6. On the ground, the Earth exerts a force F_0 on an astronaut. The force that the Earth exerts on this astronaut inside the Space Shuttle in low Earth orbit, 300 km above the ground, is
(a) a little less than F_0 (b) a little more than F_0
(c) exactly F_0
(d) zero, since the astronaut is weightless when in orbit.

7. A person is swinging a ball at the end of a string of length l with constant speed v. The work done by the tension T in the string over one revolution is
(a) 0 (b) $mv^2/2$ (c) $2\pi lT$
(d) undetermined by the information given.

8. The pressure exerted by a gas on the walls of the vessel that contains it is due to the
(a) change in kinetic energy of the gas molecules as they strike the walls
(b) collisions between the gas molecules
(c) repulsive force between the gas molecules

(d) change in momentum of the gas molecules as they strike the walls.

9. A Martian creature similar to an Earth frog jumps with an initial speed v_0 and attains the range R over horizontal ground. The maximum possible height reached by the creature, neglecting friction in the tenuous Martian air, is (θ being the launch angle)

(a) $\frac{R}{4}\tan\theta$ (b) $\frac{R}{4}\sin\theta$

(c) $\frac{R}{2}\tan\theta$

(d) undetermined because of missing data.

10. The work done to accelerate a truck on a horizontal road from rest to speed v

(a) is less than that required to accelerate it from v to $2v$

(b) is equal to that required to accelerate it from v to $2v$

(c) is more than that required to accelerate it from v to $2v$

(d) may be any one of the above since it depends on the force acting on the truck and the distance over which it acts.

11. If the Earth did not rotate on its axis, the magnitude of the gravitational acceleration at the Equator would be about

(a) 0.003% larger (b) 0.3% larger

(c) 0.3% smaller (d) 0.003% smaller.

12. You want to apply a force on a box so that it moves with constant speed across a horizontal floor. The coefficient of kinetic friction between the box and the floor is μ_k. Of the four following cases, the force you apply on the box will be smallest when you

(a) push on it with a force applied at an angle $0 < \theta < 90°$ downward from the horizontal

(b) pull on it with a force applied at the same angle as in (a), upward from the horizontal

(c) do either (a) or (b) since the applied force is the same

(d) push or pull with a force applied horizontally.

13. An electric current runs counterclockwise in a rectangular loop around the outside edge of this page, which lies flat on your table. A uniform magnetic field is then turned on, directed parallel to the page from top to bottom. The magnetic force on the page will cause

(a) the left edge to lift up

(b) the right edge to lift up

(c) the top edge to lift up

(d) the bottom edge to lift up.

14. A car has a maximum acceleration of 3.0 m/s^2. Its maximum acceleration while towing another car twice its mass, assuming no skidding, would be

(a) 3.0 m/s^2 (b) 1.5 m/s^2

(c) 1.0 m/s^2 (d) 0.5 m/s^2.

15. Two satellites of equal mass, A and B, are in concentric orbits around the Earth. The distance of B from Earth's centre is twice that of A. The ratio of the centripetal force acting on B to that acting on A is

(a) 1 (b) $\sqrt{1/2}$ (c) 1/2 (d) 1/4.

16. A proton sits at coordinates $(x, y) = (0, 0)$, and an electron at (d, h), where $d >> h$. At time $t = 0$, a uniform electric field E of unknown magnitude but pointing in the positive y direction is turned on. Assuming that d is large enough that the proton-electron interaction is negligible, the y coordinates of the two particles will be equal (at equal time)

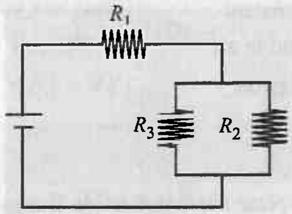
(a) at about $y = d/2000$

(b) at an undetermined value since E is unknown

(c) at about $y = d/43$

(d) none of these

17. In the circuit below we increase the resistance R_2. If I_j is the current through resistor R_j (j = 1, 2, 3), then



(a) I_1 and I_2 both increase

(b) I_1 decreases and I_2 increases

(c) I_1 and I_2 both decrease

(d) I_1 increases and I_2 decreases.

18. Two carts A and B, are placed on an air track. They are made of the same material and look identical. B is given a constant speed and collides elastically with A at rest. After the collision, both carts move in the same direction. One concludes that

(a) A is hollow (b) B is hollow

(c) A and B are identical

(d) any of the first three answers is possible.

19. The smallest length scale known in physics is the Planck length. It is an important ingredient in some currrent cosmological theories. Which of the following expressions could represent this Planck length? (see Data table.)

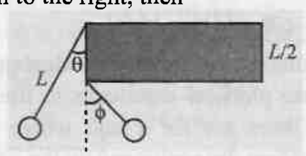
(a) $\sqrt{e^2/hc}$ (b) $\sqrt{hc/G}$ (c) $\sqrt{Ghc}$ (d) $\sqrt{hG/c^3}$.

20. The Webb space telescope, scheduled to be launched in 2010, will have a mirror 6 m in diameter. Compared

with the Hubble space telescope, whose mirror has a 2.4 m diameter, it will be able to resolve objects whose angular separation is about

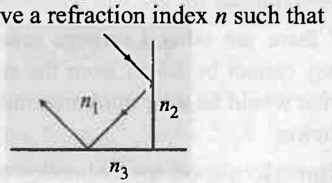
(a) 2.5 times smaller (b) 5 times smaller
(c) an order of magnitude smaller
(d) the same, the larger mirror only increases the amount of light gathered.

21. A simple pendulum of length L is suspended from the top of a flat beam of thickness $L/2$. The bob is pulled away from the beam so that it makes an angle $\theta < 30°$ with the vertical, as shown in the figure. It is then released from rest. If ϕ is the maximum angular deflection to the right, then



(a) $\phi = \theta$ (b) $\phi < \theta$
(c) $\theta < \phi < 2\theta$ (d) $\phi > 2\theta$

22. In the diagram below, light is incident on the interface between media 1 and 2 at exactly the critical angle, and is totally reflected. The light is then also totally reflected at the interface between media 1 and 3, after which it travels in a direction opposite to its initial direction. The two interfaces are perpendicular. The media must have a refraction index n such that



(a) $n_1 < n_2 < n_3$ (b) $n_1^2 - n_3^2 > n_2^2$
(c) $n_1^2 - n_2^2 > n_3^2$ (d) $n_1^2 + n_2^2 \geq n_3^2$

23. For the sake of science a physicist jumps attached to the end of a bungee cord, carrying sound measuring equipment. As he swings up and down vertically with a period of 6.0 s, he monitors the frequency of a sound source on the ground directly below him, and observes a difference of 84 Hz between the maximum and minimum frequency of the source. If the source emits at a constant 1370 Hz, and assuming no significant attenuation of his oscillations over the duration of the measurements, the amplitude of his oscillations is closest to

(a) 10 m (b) 20 m (c) 32 m (d) 15 m.

24. A person pulls a box along the ground at constant speed. Considering the Earth and the box together as a system. Which of the following is true about the net force F exerted by the person on this system and the work W she does on it ?

(a) $F = 0$ and $W = 0$ (b) $F \neq 0$ and $W = 0$
(c) $F = 0$ and $W \neq 0$ (d) $F \neq 0$ and $W \neq 0$.

25. A magnet moves inside a coil. Which of the following factors can affect the emf induced in the coil?

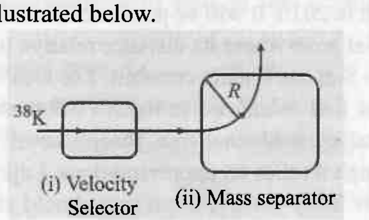
I. The speed at which the magnet moves
II. The strength of the magnet
III. The number of turns in the coil

(a) I only (b) I and II only
(c) II and III only (d) I, II and III.

SHORT ANSWER TYPE QUESTIONS

Problem 1

At TRIUMF, a large experimental particle and nuclear physics research facility on the campus of the University of British Columbia, one major programme involves the production of intense beams of unstable isotopes of alkali atoms (potassium K, rubidium Rb, francium Fr). These have the advantage that since their valence shell contains only one electron, their closed shell structure when they are ionised simplifies calculations. Many isotopes are produced when bombarding a calcium oxide target with 0.5 GeV protons from the TRIUMF accelerator. Until recently, the desired isotope was selected by means of the TRIUMF Isotope Separator On-Line (TISOL) now decommissioned and replaced by a combined separator/accelerator called ISAC—and sent as a low-speed beam to experimental areas. You are asked to design a (much) simplified version of TISOL. More specifically, you want to select ^{38}K ions whose energy is 20 keV. ^{38}K has a mass of 6.3×10^{-26} kg. Separation should proceed in two steps, as illustrated below.



The figure shows the desired path of a 20 keV ^{38}K ion through the system. This path is to be achieved by means of suitable uniform time-independent electromagnetic fields. Interactions between ions can be neglected here.

(a) In the first step, out of all ions (^{38}K or not) entering the velocity selector from the left, only those that have a speed corresponding to a 20 keV ^{38}K ion should be undeflected. Suggest a field configuration that can do this, draw a sketch showing the direction of the field(s), and derive as much information as you can about the magnitude of the field(s).

v is velocity of electromagnetic wave in medium

$\because\ c = \upsilon\lambda_0;\ v = \upsilon\lambda$

$\therefore\ \mu = \dfrac{\upsilon\lambda_0}{\upsilon\lambda}$

$\mu = \dfrac{\lambda_0}{\lambda}$ .....(ii)

λ_0 is wavelength of electromagnetic wave in vacuum

λ is wavelength of electromagnetic wave in medium.

$\therefore$ From (i) and (ii) it is clear that, as electromagnetic wave goes from one medium to another, it suffers a change in speed and wavelength, while frequency remains constant.

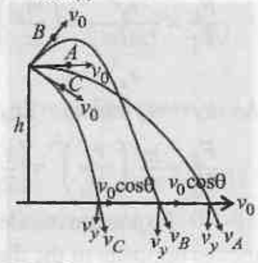
3. **(b)**

4. **(d) :** For A, $u_y = 0$; $\therefore\ v^2 - u^2 = 2as$

$\therefore\ v_y^2 - 0 = 2a_y h;\qquad v_y^2 = 2gh$

$\therefore\ v_A = \sqrt{v_y^2 + v_x^2} = \sqrt{2gh + v_0^2}$

$\therefore\ v_A = \sqrt{v_0^2 + 2gh}$ .....(i)



For B, $u_y = +v_0\sin\theta$

$v_y^2 - u_y^2 = 2a_y h$

$v_y^2 - (v_0\sin\theta)^2 = 2gh$

$v_y^2 = v_0^2\sin^2\theta + 2gh$

$\therefore\ v_B = \sqrt{v_y^2 + v_x^2}$

$= \sqrt{(v_0^2\sin^2\theta + 2gh) + (v_0\cos\theta)^2}$

$\therefore\ v_B = \sqrt{v_0^2 + 2gh}$ .....(ii)

For C, $u_y = -v_0\sin\theta$; Now, $v_y^2 - u_y^2 = 2a_y h$

$v_y^2 - (-v_0\sin\theta)^2 = 2gh;\qquad v_y^2 = v_0^2\sin^2\theta + 2gh$

$\therefore\ v_C = \sqrt{v_x^2 + v_y^2}$

$= \sqrt{(v_0\cos\theta)^2 + (v_0^2\sin^2\theta + 2gh)}$

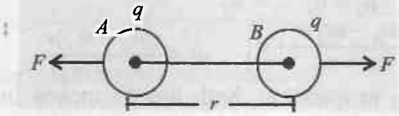
$v_C = \sqrt{v_0^2 + 2gh}$ .....(iii)

From (i), (ii) and (iii), we have

$v_A = v_B = v_C$

Hence, option (d) is correct.

5. **(a) :**



Let initial charge on identical spheres A and B are,

$q_A = q$; $q_B = q$.

$\therefore$ Force experienced by A and B due to one another is,

$F = \dfrac{Kq_Aq_B}{r^2}$; $\qquad F = \dfrac{Kq^2}{r^2}$ .....(i)

According to question, initial charge on third identical sphere C is zero, *i.e.*, $q_C = 0$.

When C is in contact with A,

$q_C = q_A = \dfrac{q+0}{2} = \dfrac{q}{2}$

When C is in contact with B,

$q_C = q_B = \dfrac{\frac{q}{2} + q}{2} = \dfrac{3q}{4}$

Now, charges on A and B after contact with C are $\dfrac{q}{2}$ and $\dfrac{3q}{4}$ respectively.

$\therefore$ Force between A and B is now,

$F' = \dfrac{K \cdot \frac{q}{2} \cdot \frac{3q}{4}}{r^2} = \dfrac{3}{8}\dfrac{Kq^2}{r^2}$ [using (i)]

$\therefore\ F' = \dfrac{3}{8}F$; $F' = \dfrac{3F}{8}$

6. **(a) :** Force experienced by astronaut at the ground,

$F_0 = \dfrac{GMm}{R^2}$

where, m = mass of astroanaut, M = mass of earth, R = radius of earth

Now, force experienced by astronaut at a height h above ground is,

$F_h = \dfrac{GMm}{(R+h)^2}$; $\dfrac{F_h}{F_0} = \dfrac{GMm}{(R+h)^2} \Big/ \dfrac{GMm}{R^2}$

$\dfrac{F_h}{F_0} = \dfrac{R^2}{(R+h)^2}$ $\quad \dfrac{F_h}{F_0} = \dfrac{1}{\left(\dfrac{R+h}{R}\right)^2} = \dfrac{1}{\left(1+\dfrac{h}{R}\right)^2}$

$\dfrac{F_h}{F_0} = \left(1+\dfrac{h}{R}\right)^{-2} = \left(1-\dfrac{2h}{R}\right)$(for h much less than R)

$\therefore\ F_h = F_0\left(1-\dfrac{2h}{R}\right)$; $\therefore\ F_h < F_0$

7. **(a) :** Displacement of ball in one revolution is zero.

$\therefore$ Work done is zero

8. **(d) :** Pressure, $P \propto$ Force (F)

But, $F \propto \dfrac{\Delta p}{\Delta t}$ (Rate of change of momentum)

$\therefore\ P \propto \Delta p$.

9. **(a) :** Range, $R = \dfrac{2v_0^2\sin\theta\cos\theta}{g}$ .....(i)

Maximum possible height,

$H = \dfrac{v_0^2\sin^2\theta}{2g}$ .....(ii)

Dividing (ii) by (i) we get,

$\dfrac{H}{R} = \dfrac{\frac{v_0^2\sin^2\theta}{2g}}{\frac{2v_0^2\sin\theta\cos\theta}{g}} = \dfrac{\sin\theta.\sin\theta}{4\sin\theta\cos\theta}$

$\dfrac{H}{R} = \dfrac{1}{4}\tan\theta$; $\therefore\ H = \dfrac{R\tan\theta}{4}$

v is velocity of electromagnetic wave in medium

$\because\ c = \upsilon\lambda_0;\ v = \upsilon\lambda$

$\therefore\ \mu = \dfrac{\upsilon\lambda_0}{\upsilon\lambda}$

$\mu = \dfrac{\lambda_0}{\lambda}$ .....(ii)

λ_0 is wavelength of electromagnetic wave in vacuum

λ is wavelength of electromagnetic wave in medium.

$\therefore$ From (i) and (ii) it is clear that, as electromagnetic wave goes from one medium to another, it suffers a change in speed and wavelength, while frequency remains constant.

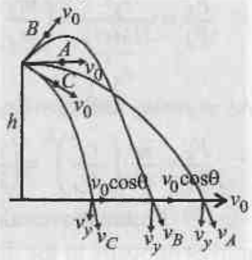
3. (b)

4. (d) : For A, $u_y = 0$; $\therefore\ v^2 - u^2 = 2as$

$\therefore\ v_y^2 - 0 = 2a_yh;\quad v_y^2 = 2gh$

$\therefore\ v_A = \sqrt{v_y^2 + v_x^2} = \sqrt{2gh + v_0^2}$

$\therefore\ v_A = \sqrt{v_0^2 + 2gh}$ .....(i)



For B, $u_y = +v_0\sin\theta$

$v_y^2 - u_y^2 = 2a_yh$

$v_y^2 - (v_0\sin\theta)^2 = 2gh$

$v_y^2 = v_0^2\sin^2\theta + 2gh$

$\therefore\ v_B = \sqrt{v_y^2 + v_x^2}$

$= \sqrt{(v_0^2\sin^2\theta + 2gh) + (v_0\cos\theta)^2}$

$\therefore\ v_B = \sqrt{v_0^2 + 2gh}$ .....(ii)

For C, $u_y = -v_0\sin\theta$; Now, $v_y^2 - u_y^2 = 2a_yh$

$v_y^2 - (-v_0\sin\theta)^2 = 2gh;\quad v_y^2 = v_0^2\sin^2\theta + 2gh$

$\therefore\ v_C = \sqrt{v_x^2 + v_y^2}$

$= \sqrt{(v_0\cos\theta)^2 + (v_0^2\sin^2\theta + 2gh)}$

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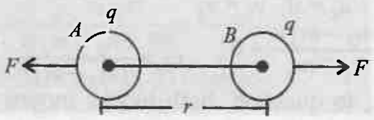

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$\dfrac{H}{R} = \dfrac{1}{4}\tan\theta$; $\therefore\ H = \dfrac{R\tan\theta}{4}$

10. (a) : Work done = Change in kinetic energy

Case I: $K_i = 0$; $K_f = \frac{1}{2}mv^2$; $\Delta K = \frac{1}{2}mv^2$

$\therefore \quad W_1 = \frac{1}{2}mv^2$

Case II : $K_i = \frac{1}{2}mv^2$; $K_f = \frac{1}{2}m(2v)^2 = 4.\frac{1}{2}mv^2$

$\Delta K = 4\cdot\frac{1}{2}mv^2 - \frac{1}{2}mv^2$; $\Delta K = \frac{3}{2}mv^2$

$\therefore \quad W_2 = \frac{3}{2}mv^2$; $\therefore\ W_2 = 3W_1$ *i.e.*, $W_1 = \frac{W_2}{3}$

11. (b) : Value of acceleration due to gravity on its equator is

$g' = g - \omega^2 R$

As earth stops rotating, value of g increases by $\omega^2 R$

$\therefore$ % increase in $g = \frac{\omega^2 R}{g} \times 100$

$= \left(\frac{2\pi}{T}\right)^2 \times \frac{R}{g} \times 100$

$= \frac{4\pi^2}{(24\times60\times60)^2} \times \frac{6.38\times10^6}{9.80} \times 100$

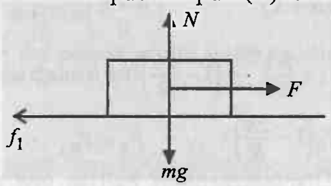
$= \frac{4\times9.86}{(86400)^2} \times \frac{6.38\times10^8}{9.80}$

$= \frac{4\times9.86}{746496\times10^4} \times \frac{638}{980} \times 10^8 = \frac{4\times986\times638}{746496\times980} \times 10^2$

$= 3.44 \times 10^{-3} \times 10^2 = 0.34\%$

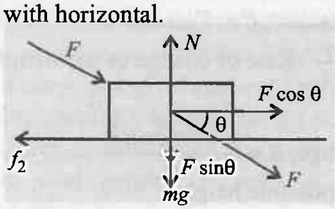
$\therefore$ g increases by 0.3%

12. (b) : Case I : When push or pull (F) is horizontal.



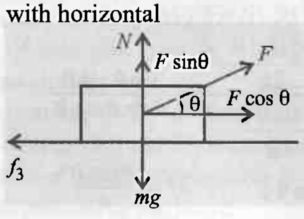
$f_1 = \mu_k mg$ .....(i)

Case II : When push on the block is downward at angle $0 < \theta < 90°$ with horizontal.



$N = mg + F\sin\theta$ $\therefore$ $f_2 = \mu_k(mg + F\sin\theta)$ ....(ii)

Case III : When pull F on the block is upward at angle θ $(0 < \theta < 90°)$ with horizontal



$N = (mg - F\sin\theta)$

$\therefore\ f_3 = \mu_k(mg - F\sin\theta)$ ....(iii)

then, $f_3 < f_1 < f_2$. Hence, option (b) is correct

13. (c) : Use Fleming left hand rule.

14. (c) : $F = ma$

$\therefore\ a = \frac{F}{m} = 3.0\,\text{m/s}^2$ ....(i)

where m is mass of car.

In towing another car of mass $2m$.

acceleration of car, $a' = \frac{F}{(m+2m)}$

$a' = \frac{F}{3m} = \left(\frac{F}{m}\right)\times\frac{1}{3} = \frac{3.0}{3}\,\text{m/s}^2$

$\therefore\ a' = 1.0\,\text{m/s}^2$

15. (d) : Centripetal force is balanced by gravitational force of acceleration

$$\therefore\ \frac{F_B}{F_A} = \frac{\dfrac{GMm_B}{r_B^2}}{\dfrac{GMm_A}{r_A^2}} = \left(\frac{m_B}{m_A}\right)\cdot\left(\frac{r_A}{r_B}\right)^2$$

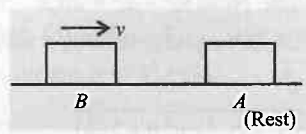
As $m_A = m_B$ and $r_B = 2r_A$

$\therefore\ \frac{F_B}{F_A} = \frac{m}{m}\left(\frac{r_A}{2r_A}\right)^2 = \left(\frac{1}{2}\right)^2$; $\therefore\ \frac{F_B}{F_A} = \frac{1}{4}$

16. (d) : Proton moves along the direction of $\vec{E}$. Electron moves opposite to the direction of $\vec{E}$.

17. (c) : As R_2 increases, I_2 decreases. Further increase in effective resistance, decreases current through the circuit.

18. (a) :



In elastic collision, velocity of body B after collision is,

$v_1 = \frac{(m_1 - m_2)u_1}{m_1 + m_2} + \frac{2m_2u_2}{m_1 + m_2}$

Here, $m_1 = m_B$, $m_2 = m_A$

$u_1 = v$, $u_2 = 0$; $v_1 = v_B$

$\therefore\ v_B = \frac{(m_B - m_A)v}{m_B + m_A} + 0$; $v_B = \frac{(m_B - m_A)v}{(m_B + m_A)}$

According to question, both blocks moves in same direction.

i.e. v_B is positive. or $v_B > 0$; $\therefore$ $m_B - m_A > 0$

i.e. $m_B > m_A$.

$\therefore$ Block A may be hollow.

19. (d) : $[h] = ML^2T^{-1}$; $[c] = LT^{-1}$

$[G] = M^{-1}L^3T^{-2}$

$$\sqrt{\frac{hG}{c^3}} = \sqrt{\frac{ML^2T^{-1}\cdot M^{-1}L^3T^{-2}}{L\,T^{-3}}} = \sqrt{L^2}$$

$\therefore \sqrt{\frac{hG}{c^3}} = L$ = Dimension of length.

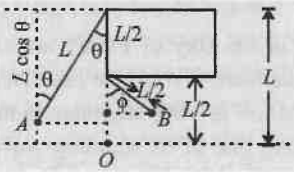
Hence, option (d) is correct.

20. (a) : Angular separation of telescope, $\theta \propto \frac{1}{d}$

d is diameter of mirror of telescope.

$$\therefore \frac{\theta_1}{\theta_2} = \frac{d_2}{d_1} = \frac{6\text{ m}}{2.4\text{ m}} \simeq \frac{5}{2}\text{ m} = 2.5\text{ m} \;;\; \therefore \theta_2 = \frac{\theta_1}{2.5\text{ m}}$$

21. (c) :



At A, K.E = 0, P.E = $mg[L - L\cos\theta]$

P.E = $mgL(1 - \cos\theta)$

$\therefore$ Total energy at A, E_A = K.E + P.E

$\therefore$ $E_A = mgL(1 - \cos\theta)$ ....(i)

At B, K.E = 0

P.E = $mg\left[\frac{L}{2} - \frac{L}{2}\cos\phi\right] = mg\frac{L}{2}(1 - \cos\phi)$

$\therefore$ Total energy at B.

$E_B = \frac{mgL}{2}(1 - \cos\phi)$ .....(ii)

Since energy is conserved.

$\therefore$ $E_A = E_B$

$\Rightarrow$ $mgL(1 - \cos\theta) = \frac{mgL}{2}(1 - \cos\phi)$

$1 - \cos\theta = \frac{1 - \cos\phi}{2}$

$2 - 2\cos\theta = 1 - \cos\phi$

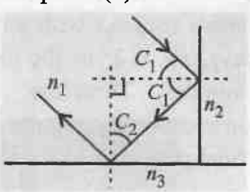
$2\cos\theta - \cos\phi = 1$

$2\cos\theta = 1 + \cos\phi$

$\cos\theta = \frac{1 + \cos\phi}{2}$ $\therefore$ $\theta < \phi < 2\theta$

Hence option (c) is correct.

22. (c) :



For refraction at (1-2) interface,

$n_1 \sin C_1 = n_2 \sin 90°$

$\therefore$ $\sin C_1 = \frac{n_2}{n_1}$ .....(i)

For refraction at (1 - 3) interface,

$n_1 \sin C_2 = n_3 \sin 90°$

$\therefore$ $\sin C_2 = \frac{n_3}{n_1}$ .....(ii)

Now from the diagram, it is clear that

$C_1 + C_2 = 90°$

$\therefore$ $C_2 = (90° - C_1)$

From (ii) $\sin(90° - C_1) = \frac{n_3}{n_1}$

$\therefore$ $\cos C_1 = \frac{n_3}{n_1}$ ....(iii)

Squaring and adding (i) and (iii) we get

$\sin^2 C_1 + \cos^2 C_1 = \frac{n_2^2}{n_1^2} + \frac{n_3^2}{n_1^2}$

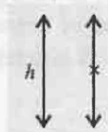
$\Rightarrow$ $1 = \frac{n_2^2 + n_3^2}{n_1^2}$

$\therefore$ $n_1^2 = n_2^2 + n_3^2$ $\Rightarrow n_1^2 - n_2^2 = n_3^2$.

Hence option (c) is correct.

23. (a) : $\upsilon = \frac{\upsilon_0(330 + v)}{330}$

v = velocity of the observer



$\therefore$ $330(\upsilon - \upsilon_0) = \upsilon_0.v$

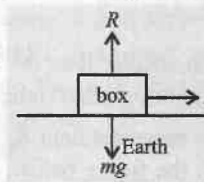
$330 \cdot 84 = 1370\,v$

$\therefore$ $v = 20.23$ m/s

$v^2 = 2gh \Rightarrow h = \frac{(20.23)^2}{2 \times 10} = 20.46 = 20$ m

Amplitude is $\frac{20\text{ m}}{2} = 10$ m.

24. (a) :

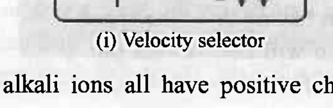


Assume that there is no friction F = 0 because once the box has started moving, it is moving with a constant velocity. mg is acting down and $R = mg$. No work is done because unless the body is lifted, there is no work done, once motion has started.

25. (d)

Problem 1

(a) As shown in the figure below, we can use a uniform electric field, $\vec{E}$, directed downward in the plane of the page, and a uniform magnetic field, $\vec{B}_1$, directed into the page. ($\vec{E}$ directed upward and $\vec{B}_1$ out of the page will also work.)



(i) Velocity selector

Since the alkali ions all have positive charge e, they

experience

- an electric force $\vec{F}_E = e\vec{E}$, directed downward in the plane of the page
- a magnetic force $\vec{F}_M = e\vec{v} \times \vec{B}_1$, where v is the velocity of an ion. From the right-hand rule for vector products, it is directed upward in the plane of the page, for v directed to the right, the magnitude of $\vec{F}_M$ is simply evB.

For a given velocity $\vec{v}_0$, there exist magnitudes of $\vec{E}$ and $\vec{B}_1$ such that the magnetic and electric forces balance each other. This condition is achieved when $F_E = F_M$, or $eE = ev_0B_1$. Then all ions which have speed

$$v_0 = \frac{E}{B}$$

when they enter the velocity selector will not be deflected. Ions with other speeds will be deflected and can be extracted from the initial beam. Only the ratio E / B is determined by the condition

$$\frac{E}{B} = \sqrt{\frac{2K_0}{m_0}}$$

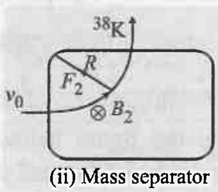
where m_0 is the mass of a ^{38}K ion and $K = m_0v_0^2/2$.

$$\text{Then, } \frac{E}{B} = \sqrt{\frac{2(2.0\times10^4\,\text{eV})(1.6\times10^{-19}\,\text{C})}{6.3\times10^{-26}\,\text{kg}}}$$

$$= 3.2 \times 10^5 \text{ m/s}$$

Note that this value is much smaller than the speed of light, consistent with our ignoring relativistic effects.

(b) In this case, the uniform magnetic field $\vec{B}_2$ directed into the page, as shown in the figure below, exerts a centripetal force $\vec{F}_2$ on incoming ions, giving them a circular trajectory of radius R. It does not change their energy (and speed) since magnetic fields do no work. The direction of deflection of the ions is determined from the right-hand rule applied to $\vec{F}_2 = e\vec{v}_0 \times \vec{B}_2$.



(ii) Mass separator

Since v_0 and B_2 are perpendicular, we have $F_2 = ev_0B_2$. Using the general expression for a centripetal force, $F_2 = mv_0^2 / R$, where m is the mass of an ion, we obtain

$$R = \frac{mv_0}{eB_2}$$

All incoming ions having the same speed, to each ionic mass in the beam will correspond one value of R in a given magnetic field. If only ^{38}K ions are to have a trajectory with radius of curvature R_0, we should use a field

$$B_2 = \frac{mv_0}{eR_0} = \frac{1}{R_0}\sqrt{\frac{2m_0K_0}{e^2}}$$

With the data supplied, we have

$$B_2 = \frac{1}{R_0}\sqrt{\frac{2K_0(\text{eV})}{e/m_0}} \qquad K_0 \text{ in eV}$$

$$= \frac{1}{2.1\,\text{m}}\sqrt{\frac{2(2.0\times10^4\,\text{eV})}{(1.6\times10^{-19}\,\text{C})/(6.3\times10^{-26}\,\text{kg})}} = 0.060\text{ T}$$

Problem 2

If the high tides in the Bay of Fundy are caused by a resonance mechanism, it must be because the tidal forces from the Moon driving seawater in and out of the bay are exciting one of its standing wave modes. The rise and fall of the tide can be modelled by a wave with extremely long wavelength propagating on the water. The boundary conditions at the mouth and the far end of the bay mimic those of a standing wave on a string with on end fixed (mouth), where the vertical displacement is minimum, and the other free (far end). where displacement is maximum. This mode would have a wavelength $\lambda = 4L$, where L is the length of the string or, here, the length of the bay $L = 260$ km.

with $v = 25$ m/s the speed of the waves, their period is

$$T = \frac{\lambda}{v} = \frac{4L}{v} = \frac{4(2.60\times10^5\,\text{m})}{25\text{ m/s}} = 4.16\times10^4\text{ s}$$

$$= 11.6 \text{ hours}$$

Now we expect the period of the tides to be about 12.4 hours. Indeed, if the Moon had a fixed position with respect to the Earth, the two tidal bulges (high tides) on Earth would move in the direction opposite the Earth's rotation with one passing through a given position every 12 hours. But the Moon moves in its own orbit with the Earth's rotation with an average period of about 29 days, *i.e.* 6.2° in the sky every 12 hours or 720 minutes. Therefore, it takes 25 minutes for the Moon to cover that angular distance, and this increases the tidal period to 12.4 hours.

We have found that the period with which the water sloshes back and forth in the bay due to the Moon's tidal force is comparable to the period of the fundamental resonance mode for our admittedly crude model of the Bay of Fundy. Given the approximations involved, this is quite a good match, and it is likely that this resonance mechanism can explain why the tides are amplified.

Problem 3

(a) We are looking for a configuration where the telescope, the Earth and the Sun maintain the same relative positions in a coordinate system rotating at constant angular velocity ω. In other words, in that rotating system, the telescope has the following net acceleration

$$a = \omega^2 x - \left[\frac{GM_1}{x^2} \pm \frac{GM_2}{(R \pm x)^2}\right]$$

where the + sign is to be used when $x > R$ and the − sign when $x < R$. (Technical point: since we are working in the non-inertial frame rotating with angular velocity ω, an extra pseudo-acceleration (Coriolis) term dependent on dx / dt should also be present. With our assumption of a circular orbit, however, $dx / dt = 0$, and the Coriolis term does not contribute.)

The condition that a vanishes then reads

$$\omega^2 x = \frac{GM_1}{x^2} \pm \frac{GM_2}{(R + x)^2}$$

(b) Using Kepler's Third Law, $GM_1 = \omega^2 R^3$, and introducing the parameter $\alpha = M_2/M_1$, we can eliminate ω^2 and M_1

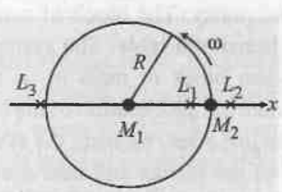
$$x = \frac{R^3}{x^2} \pm \frac{\alpha R^3}{(R \pm x)^2}$$

Multiplying by x^2/R^3 and rearranging yields, with $u = x/R$

$$u^3 - 1 = \pm \frac{\alpha u^2}{(1 \pm u)^2}$$

(c) From the result in (a), there should be a point L_1 on the axis between the Earth and the Sun where the condition that the centrifugal acceleration $\omega^2 x_1$ equals the net gravitational acceleration (which is smaller than that due to the Sun) can be satisfied for a value of ω equal to the Earth's, so that $x_1 < R$. Since the mass of the Earth is over 300000 times smaller than the Sun's, L_1 should not be very far from Earth. It is actually 1.5 million km away, one hundred times closer than the Sun. Conversely, the same condition will be satisfied at a point L_2 a bit farther than the Earth's orbit, where this time the gravitational attractions of Sun and Earth add, so that $x_2 > R$. L_2 should be (and is) at about the same distance from the Earth's orbit as L_1.

Finally, at a point L_3 on the other side of Sun, the condition is also satisfied where the gravitational acceleration due to the Sun's and the Earth's gravity reinforcing each other equals $\omega^2 x_3$. Since Earth is much farther from L_3 than from L_2, L_3 should be much closer to R than L_2. It is a good place to hide from Earth.



(d) The point labelled L_2 in the figure will be suitable for the telescope. A heat screen attached to the telescope will shield it from heat radiated by both Earth and Sun since they are always aligned as viewed from L_2, leaving the rest of the sky unobstructed for observation.

(e) Since the system shown in the figure is symmetric about the x axis, Lagrange points off the axis must come in pairs. So the minimum number is two. In fact, Lagrange found one pair of solutions off the axis, for a total of five.

❖

AIIMS | CBSE PMT | DPMT | AFMC | VMMC | EAMCET | WB-JEE | BHU | CMC | UPCPMT | Manipal PMT

Practice Paper for Medical Entrance Exam 2008

MP-PMT | MGIMS | PMDT Bihar | PMT Haryana | Kerala PMT | Raj. PMT | TNPCEE | JIPMER | CET Karnataka

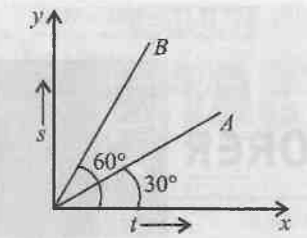
1. Which one of the following is not a unit of time?
(a) Lunar month (b) Leap year
(c) Parsec (d) Solar day

2. Suppose refractive index μ is given as
$$\mu = A + \frac{B}{\lambda^2}$$
where A and B are constants and λ is wavelength, then dimensions of B are same as that of
(a) wavelength (b) volume
(c) pressure (d) area

3. The vector sum of two forces is perpendicular to their vector differences. In that case, the forces
(a) can not be predicted
(b) are perpendicular to each other
(c) are equal to each other in magnitude
(d) are not equal to each other in magnitude

4. A body is allowed to fall from a height of 100 m. If the time taken for the first 50 m is t_1, and for the remaining 50 m is t_2, then
(a) $t_1 = t_2$ (b) $t_1 > t_2$ (c) $t_1 < t_2$
(d) depends upon the mass

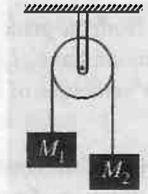
5. The displacement time graphs of two bodies A and B are shown in figure. The ratio of velocity of A, v_A to velocity of B, v_B is



(a) $\frac{1}{\sqrt{3}}$ (b) $\sqrt{3}$ (c) $\frac{1}{3}$ (d) 3

6. A projectile is thrown at an angle of 40° with the horizontal and its range is R_1. Another projectile is thrown at an angle 40° with the vertical and its range is R_2. What is the relation between R_1 and R_2?
(a) $R_1 = R_2$ (b) $R_1 = 2R_2$
(c) $R_2 = 2R_1$ (d) $R_1 = \frac{4R_2}{5}$

7. Two masses $M_1 = 5$ kg and $M_2 = 10$ kg are connected at the ends of an inextensible string passing over a frictionless pulley as shown. When the masses are released, then the acceleration of the masses will be



(a) g (b) $g/2$ (c) $g/3$ (d) $g/4$

8. A block of mass m is pulled along a horizontal surface by applying a force at an angle θ with the horizontal. If the block travels with a uniform velocity and has a displacement d and the coefficient of friction is μ, then the work done by the applied force is
(a) $\frac{\mu mgd}{\cos\theta + \mu\sin\theta}$ (b) $\frac{\mu mgd\cos\theta}{\cos\theta + \mu\sin\theta}$
(c) $\frac{\mu mgd\sin\theta}{\cos\theta + \mu\sin\theta}$ (d) $\frac{\mu mgd\cos\theta}{\cos\theta - \mu\sin\theta}$

9. Consider a car moving along a straight horizontal road with a speed of 72 km/h. If the coefficient of static friction between road and tyres is 0.5, the shortest distance in which the car can be stopped is
(a) 30 m (b) 40 m (c) 72 m (d) 20 m

10. Three point masses, each of mass m, are placed at the corner of an equilateral triangle of side l. Then the moment of inertia of this system about an axis along one side of the triangle is
(a) $3ml^2$ (b) ml^2 (c) $\frac{3}{4}ml^2$ (d) $\frac{3}{2}ml^2$

11. The moment of inertia of a body about a given axis is 1.2 kg m^2. Initially, the body is at rest. In order to produce a rotational kinetic energy of 1500 joule, an angular acceleration of 25 rad/sec^2 must be applied about that axis for a duration of
(a) 4 s (b) 2 s (c) 8 s (d) 10 s

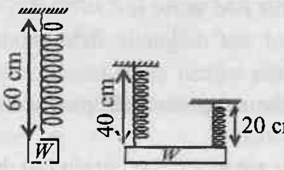
12. If the metal bob of a simple pendulum is replaced by a wooden bob, then its time period will

(a) increase (b) decrease
(c) remain the same (d) be first (a) then (b)

13. The acceleration due to gravity is g at a point r distant from the centre of earth of radius R. If $r < R$, then
(a) $g \propto r$ (b) $g \propto r^2$ (c) $g \propto r^{-1}$ (d) $g \propto r^{-2}$

14. The escape velocity for a body projected vertically upwards from the surface of earth is 11 km/sec. If the body is projected at an angle of 45° with the vertical, the escape velocity will be
(a) $11/\sqrt{2}$ km/sec (b) $11\sqrt{2}$ km/sec
(c) 2 km/sec (d) 11 km/sec

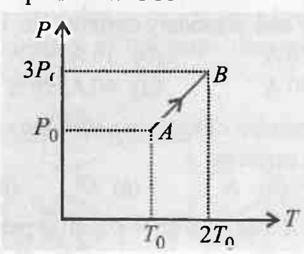
15. A block of weight W produces an extension of 9 cm when it is hung by an elastic spring of length 60 cm and is in equilibrium. The spring is cut into two parts, one of length 40 cm and the other of length 20 cm. The same load W hangs in equilibrium supported by both parts as shown in figure. The extension in cm now is



(a) 9 (b) 6 (c) 3 (d) 2

16. Two capillaries of length L and $2L$ and of radii R and $2R$ are connected in series. The net rate of flow of fluid through them will be (given rate of the flow through single capillary $X = \pi PR^4/8\eta L$)
(a) $\frac{8}{9}X$ (b) $\frac{9}{8}X$ (c) $\frac{5}{7}X$ (d) $\frac{7}{5}X$

17. Pressure versus temperature graph of an ideal gas is as shown in figure. Density of the gas at point A is ρ_0. Density at point B will be

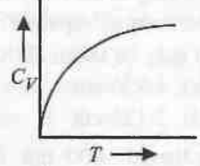


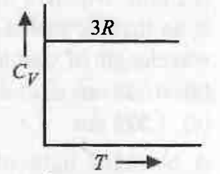
(a) $\frac{3}{4}\rho_0$ (b) $\frac{3}{2}\rho_0$ (c) $\frac{4}{3}\rho_0$ (d) $2\rho_0$

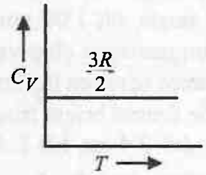
18. The latent heat of vaporisation of a substance is always
(a) greater than its latent heat of fusion
(b) greater than its latent heat of sublimation
(c) equal to its latent heat of sublimation
(d) less than its latent heat of fusion

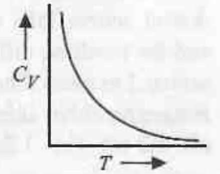
19. A reversible engine converts one-sixth of the heat input into work. When the temperature of the sink is reduced by 62°C, the efficiency of the engine is doubled. The temperatures of the source and sink are
(a) 99°C, 37°C (b) 80°C, 37°C
(c) 95°C, 37°C (d) 90°C, 37°C

20. Graph of specific heat at constant volume for a monoatomic gas is

(a) 

(b) 

(c) 

(d) 

21. If the displacement (x) and velocity v of a particle executing simple harmonic motion are related through the expression $4v^2 = 25 - x^2$ then its time period is
(a) π (b) 2π (c) 4π (d) 6π

22. A pendulum suspended from the roof of an elevator at rest has a time period T_1, when the elevator moves up with an acceleration a its time period becomes T_2, when the elevator moves down with an acceleration a, its time period becomes T_3, then
(a) $T_1 = \sqrt{(T_2 T_3)}$ (b) $T_1 = \sqrt{(T_2^2 + T_3^2)}$
(c) $T_1 = \frac{T_2 T_3 \sqrt{2}}{\sqrt{T_2^2 + T_3^2}}$ (d) none of these

23. In a sinusoidal wave, the time required for a particular point to move from maximum displacement to zero displacement is 0.17 sec. The frequency of the wave is
(a) 1.47 Hz (b) 0.36 Hz (c) 0.73 Hz (d) 2.94 Hz

24. Stationary waves of frequency 300 Hz are formed in a medium in which the velocity of sound is 1200 m/s. The distance between a node and neighbouring antinode is
(a) 1 m (b) 2 m (c) 3 m (d) 4 m

25. The refractive index of water with respect to air is 4/3 and the refractive index of glass with respect to air is 3/2. Then the refractive index of water with respect to glass is
(a) 9/8 (b) 8/9 (c) 1/2 (d) 2

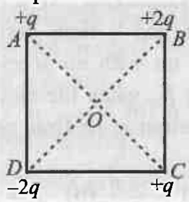
26. If one face of a prism of prism angle 30° and $\mu = \sqrt{2}$ is silvered, the incident ray retraces its initial path. The angle of incidence is
(a) 60° (b) 30° (c) 45° (d) 90°

27. A paper with two marks having separation d is held normal to the line of sight of an observer at a distance of 50 m. The diameter of the eye lens of the observer is 2 mm. Which of the following is the least value of d, so that the marks can be seen as separate? Mean wavelength of visible light may be taken 5000 Å
(a) 0.125 cm (b) 1.225 cm
(c) 1.525 cm (d) 2.125 cm

28. A beam of light of wavelength 600 nm from a distant source falls on a single slit 1.00 mm wide and the resulting diffraction pattern is observed on a screen 2 m away. The distance between the first dark fringes on either side of the central bright fringe is
(a) 1.2 cm (b) 1.2 mm (c) 2.4 cm (d) 2.4 mm

29. A Nicol prism is based on the principle of
(a) refraction (b) scattering
(c) dichroism (d) double refraction

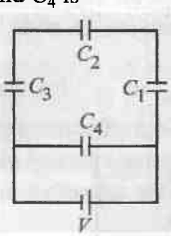
30. Four charges are arranged at the corners of a square $ABCD$ as shown in the figure. The force on the positive charge kept at the centre O is



(a) zero (b) along the diagonal AC
(c) along the diagonal BD
(d) perpendicular to side AB

31. Electric potential at any point is $V = -5x + 3y + \sqrt{15}z$ then the magnitude of electric field is
(a) $3\sqrt{2}$ (b) $4\sqrt{2}$ (c) $5\sqrt{2}$ (d) 7

32. A network of four capacitors of capacity equal to $C_1 = C$, $C_2 = 2C$, $C_3 = 3C$ and $C_4 = 4C$ are connected to a battery as shown in the figure. The ratio of the charges on C_2 and C_4 is



(a) 4/7 (b) 3/22 (c) 7/4 (d) 22/3

33. The number of dry cells, each of e.m.f. 1.5 volt and internal resistance 0.5 Ω that must be joined in series with a resistance of 20 ohm so as to send a current of 0.6 ampere through the circuit is
(a) 2 (b) 8 (c) 10 (d) 12

34. In an experiment to measure the internal resistance of a cell by a potentiometer, it is found that the balance point is at a length of 2 m, when the cell is shunted by a 5 Ω resistance and at a length of 3 m, when the cell is shunted by a 10 Ω resistance. The internal resistance of the cell is then
(a) 1.5 Ω (b) 10 Ω (c) 15 Ω (d) 1 Ω

35. The temperature of inversion of a thermocouple is 620°C and the neutral temperature is 300°C. What is the temperature of cold junction?
(a) 320°C (b) 20°C (c) –20°C (d) 40°C

36. Two infinitely long parallel wires carry equal currents in same direction. The magnetic field at a mid point in between the two wires is
(a) square of the magnetic field produced due to each of the wires
(b) half of the magnetic field produced due to each of the wires
(c) twice the magnetic field produced due to each of the wires
(d) zero

37. An arc of a circle of radius R subtends an angle $\frac{\pi}{2}$ at the centre. It carries a current I. The magnetic field at the centre will be
(a) $\frac{\mu_0 I}{2R}$ (b) $\frac{\mu_0 I}{8R}$ (c) $\frac{\mu_0 I}{4R}$ (d) $\frac{2\mu_0 I}{5R}$

38. A transformer with efficiency 80% works at 4 kW and 100 V. If the secondary voltage is 200 V, then the primary and secondary currents are respectively
(a) 40 A, 16 A (b) 16 A, 40 A
(c) 20 A, 40 A (d) 40 A, 20 A

39. If N is the number of turns in a coil, the value of self-inductance varies as
(a) N^0 (b) N (c) N^2 (d) N^{-2}

40. A particle A has charge $+q$ and a particle B has charge $+4q$ with each of them having the same mass m. When allowed to fall from rest, the ratio of their speeds v_A/v_B will become
(a) 2 : 1 (b) 1 : 2 (c) 1 : 4 (d) 4 : 1

41. The energy of a photon is equal to the kinetic energy of a proton. The energy of the photon is E. Let λ_1 be the de Broglie wavelength of the proton and λ_2 be the wavelength of the photon. The ratio λ_1/λ_2 is

proportional to
(a) E^0 (b) $E^{1/2}$ (c) E^{-1} (d) E^{-2}

42. The moment of momentum for an electron in second orbit of hydrogen atom as per Bohr's model is
(a) $\frac{h}{\pi}$ (b) $2\pi h$ (c) $\frac{2h}{\pi}$ (d) $\frac{\pi}{h}$

43. The angular speed of the electron in the n^{th} orbit of Bohr's hydrogen atom is
(a) directly proportional to n
(b) inversely proportional to $\sqrt{n}$
(c) inversely proportional to n^2
(d) inversely proportional to n^3

44. In hydrogen spectrum, the shortest wavelength in Balmer series is λ. The shortest wavelength in Brackett series will be
(a) 2λ (b) 4λ (c) 9λ (d) 16λ

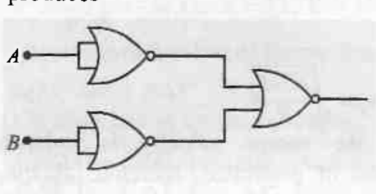
45. An element with atomic number Z = 11 emits K_α X-ray of wavelength λ, then the atomic number of the element which emits K_α X-ray of wavelength 4λ is
(a) 11 (b) 44 (c) 6 (d) 5

46. If N_0 is the original mass of the substance of half life period 5 years, then the amount of substance left after 15 years is
(a) $N_0/2$ (b) $N_0/3$ (c) $N_0/4$ (d) $N_0/8$

47. The current gain for transistor working as common base amplifier is 0.96. If the emitter current is 7.2 mA, then the base current is
(a) 0.29 mA (b) 0.35 mA
(c) 0.39 mA (d) 0.43 mA

48. The electrical conductivity of a semiconductor increases when electromagnetic radiation of wavelength shorter than 2480 nm is incident on it. The band gap (in eV) for the semiconductor is
(a) 0.9 (b) 0.7 (c) 0.5 (d) 0.1

49. The combination of the gates shown in the figure below produces



(a) NOR gate (b) AND gate
(c) OR gate (d) NAND gate

50. A message signal of frequency 10 kHz and peak voltage of 10 volts is used to modulate a carrier of frequency 1 MHz and peak voltage of 20 volts. The modulation index is
(a) 0.5 (b) 1 (c) 1.5 (d) 12

SOLUTIONS

1. (c) : Parsec is a unit of distance.

2. (d) : As $\mu = \frac{\text{velocity of light in vacuum}}{\text{velocity of light in medium}}$, hence μ is dimensionless. Thus each term on the RHS of given equation should be dimensionless.

$\therefore$ $\frac{B}{\lambda^2}$ is dimensionless, *i.e.*, B should have dimensions of λ^2, *i.e.*, cm^2, *i.e.*, area.

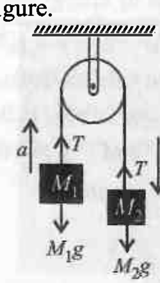
3. (c) : $\vec{S} = \vec{F}_1 + \vec{F}_2$ and $\vec{D} = \vec{F}_1 - \vec{F}_2$
As two vectors are perpendicular to each other, hence $\vec{S} \cdot \vec{D} = 0$
or $(\vec{F}_1 + \vec{F}_2) \cdot (\vec{F}_1 - \vec{F}_2) = 0$
or $(\vec{F}_1)^2 - (\vec{F}_2)^2 = 0$
or $|\vec{F}_1|^2 - |\vec{F}_2|^2 = 0$
or $|\vec{F}_1|^2 = |\vec{F}_2|^2$ or $|\vec{F}_1| = |\vec{F}_2|$

4. (b) : $s = \frac{1}{2}gt_1^2$
or $t_1^2 = \frac{50 \times 2}{g} = \frac{100}{g}$ or $t_1 = \frac{10}{\sqrt{g}}$
and $100 = \frac{1}{2}gt^2$ or $t = \frac{10\sqrt{2}}{\sqrt{g}}$
$\therefore$ $t_2 = t - t_1 = \frac{10}{\sqrt{g}}(\sqrt{2} - 1) = 0.4t_1$ *i.e.*, $t_1 > t_2$

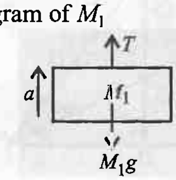
5. (c) : Velocity is the slope of the displacement time graph
$\frac{v_A}{v_B} = \frac{\tan 30°}{\tan 60°} = \frac{(1/\sqrt{3})}{(\sqrt{3})} = \frac{1}{3}$

6. (a) : R is same for both θ and $(90° - \theta)$.
If angle w.r.t. vertical is 40° then w.r.t. horizontal direction it will be 90° – 40° = 50°.

7. (c) : Since $M_2 > M_1$, therefore M_2 moves downwards and M_1 moves upwards with an acceleration a as shown in the figure.



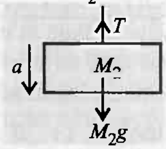
Free body diagram of M_1



The equation of motion for M_1 is

$$T - M_1 g = M_1 a \quad ......(i)$$

Free body diagram of M_2



The equation of motion for M_2 is

$$M_2 g - T - M_2 a \quad ......(ii)$$

Adding (i) and (ii), we get

$$a = \frac{(M_2 - M_1)\,g}{M_2 + M_1} = \frac{(10-5)g}{(10+5)} = \frac{g}{3}$$

8. (b) : Because the block moves with a uniform velocity, the resultant force is zero. Resolving F into horizontal component $F\cos\theta$ and vertical component $F\sin\theta$, we get

$R + F\sin\theta = mg$ or $R = mg - F\sin\theta$

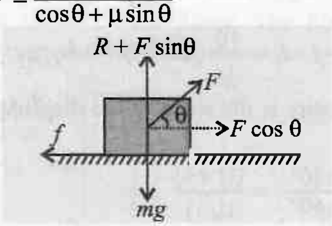
Also $f = \mu R = \mu(mg - F\sin\theta)$

But $F\cos\theta = f$

or $F\cos\theta = \mu(mg - F\sin\theta)$

or $F(\cos\theta + \mu\sin\theta) = \mu mg$

$$\therefore \quad F = \frac{\mu mg}{\cos\theta + \mu\sin\theta}$$



Work $W = Fs\cos\theta$

$$\therefore \quad W = \frac{\mu mgd\cos\theta}{\cos\theta + \mu\sin\theta} \quad (\because s = d)$$

9. (b) : Initial kinetic energy of the car $= \frac{1}{2}mv^2$

Work done against friction $= \mu mgs$

From conservation of energy

$\mu mgs = \frac{1}{2}mv^2$ or $s = (v^2/2\mu g)$

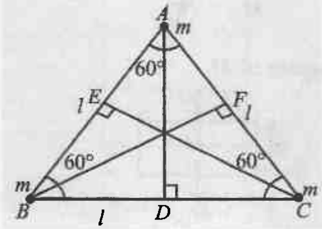
Stopping distance, $s = (v^2/2\mu g)$

Given, $v = 72$ km/h $= 72 \times \frac{5}{18} = 20$ m/s

$\mu = 0.5$ and $g = 10$ ms^{-2}

$$\therefore \quad s = \frac{20\times 20}{2\times 0.5\times 10} = 40 \text{ m}$$

10. (c) :



Moment of inertia about BC is

$I_{BC} = m(0)^2 + m(0)^2 + m(AD)^2$

Since

$$AD = \sqrt{AB^2 - \left(\frac{BC}{2}\right)^2} = \sqrt{l^2 - \frac{l^2}{4}} = \frac{\sqrt{3}l}{2}$$

$$I_{BC} = m\left(\frac{\sqrt{3}}{2}l\right)^2 = \frac{3}{4}ml^2$$

Similarly, we find the moment of inertia about AB is

$I_{AB} = m(0)^2 + m(0)^2 + m(CE)^2$

In right angle ΔBEC

$\sin 60° = \frac{CE}{BC} = \frac{CE}{l}$ or $CE = l\sin 60°$

or $CE = \frac{\sqrt{3}}{2}l$

$$I_{AB} = m\left(\frac{\sqrt{3}}{2}l\right)^2 = \frac{3ml^2}{4}$$

Moment of inertia along AC is I_{AC}

$= m(0)^2 + m(0)^2 + m(BF)^2$

In right angle ΔBFC

$\sin 60° = \frac{BF}{BC} = \frac{BF}{l}$ or $BF = l\sin 60°$

or $BF = l\frac{\sqrt{3}}{2}$

$$I_{AC} = m\left(\frac{\sqrt{3}}{2}l\right)^2 = \frac{3ml^2}{4}$$

11. (b) : $K_R = \frac{1}{2}I\omega^2 = \frac{1}{2}I(\alpha t)^2 = \frac{1}{2}I\alpha^2 t^2$

$1500 = \frac{1}{2} \times 1.2 \times (25)^2\, t^2$

or $t^2 = 4$ or $t = 2$ s

12. (c) : Time period of a simple pendulum is

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Time period of a simple pendulum is independent on the material of the bob. Hence when a metal bob is replaced by a wooden bob its time period remains the same.

13. (a)

14. (d) : $v_e = \sqrt{\frac{2GM_e}{R_e}}$

Since the escape velocity is independent of direction of projection, therefore escape velocity of the body, projected at an angle of 45° with the vertical will be same, *i.e.*, 11 km/sec.

15. (d) : Spring constant for original spring be k (say)

$W = (k \times 9)$ or $k = \frac{W}{9}$

As spring constant is inversely proportional to length, so spring constant for spring of k and for spring of 20 cm length $= 3k$.

Spring constant of combination of two shorter springs

$$= \frac{3k}{2} + 3k = \frac{9k}{2}$$

$\therefore\ W = \frac{9}{2}k(x')$, or $9k = \frac{9}{2}kx'$

$\therefore\ x' = 2$ cm

16. (a) : Fluid resistance is given by

$$R = \frac{8\eta l}{\pi r^4}$$

When two capillary tubes of same size are connected in series, then equivalent fluid resistance is

$$R_s = R_1 + R_2 = \frac{8\eta L}{\pi R^4} + \frac{8\eta 2L}{\pi(2R)^4} = \frac{8\eta L}{\pi R^4} \times \frac{9}{8}$$

Rate of flow $= \frac{P}{R_s} = \frac{\pi P R^4}{8\eta L} \times \frac{8}{9}$

$= \frac{8}{9}X \left(\text{as } X = \frac{\pi P R^4}{8\eta L}\right)$

17. (b) : $\rho = \frac{PM}{RT}$ or $\rho \sim \frac{P}{T}$

or $\left(\frac{P}{T}\right)_A = \frac{P_0}{T_0}$ and $\left(\frac{P}{T}\right)_B = \frac{3}{2}\left(\frac{P_0}{T_0}\right)$

or $\left(\frac{P}{T}\right)_B = \frac{3}{2}\left(\frac{P}{T}\right)_A$

$\therefore\ \rho_B = \frac{3}{2}\rho_A = \frac{3}{2}\rho_0$

18. (a)

19. (a) : $\eta_1 = 1 - \frac{T_L}{T_H} = \frac{W}{Q_1} = \frac{1}{6}$

or $5T_H - 6T_L = 0$ ...(i)

$\eta_2 = 1 - \frac{T_L - 62}{T_H} = 2\eta_1 = \frac{1}{3}$

or $2T_H - 3T_L = -186$ ...(ii)

Solving (i) and (ii), we get

$\therefore\ T_H = 372\ \text{K} = 99°\text{C}$

$T_L = \frac{5}{6}T_H = \frac{5}{6} \times 372\ \text{K} = 310\ \text{K} = 37°\text{C}$

20. (c) : According to first law of thermodynamics

$\Delta Q = \Delta U + P\Delta V$

If ΔQ is absorbed at constant volume, $\Delta V = 0$

$$C_V = \left(\frac{\Delta Q}{\Delta T}\right)_V = \left(\frac{\Delta U}{\Delta T}\right)_V = \frac{\Delta U}{\Delta T}$$

for an ideal monoatomic gas

$\frac{\Delta U}{\Delta T} = \frac{3}{2}R$; $C_V = \frac{3}{2}R$

21. (c) $4v^2 = 25 - x^2$

Differentiating, $4\left(2v \cdot \frac{dv}{dt}\right) = -2x\frac{dx}{dt}$

or $4\frac{dv}{dt} = -x \quad \left(\because \frac{dx}{dt} = v\right)$

or $4a = -x \quad \left(\because \frac{dv}{dt} = a\right)$

or $a = -\frac{1}{4}x$

$\therefore\ \omega^2 = \frac{1}{4}$ and $T = \frac{2\pi}{\omega} = \frac{2\pi}{1/2} = 4\pi$ sec

22. (c) : $T_1 = 2\pi\sqrt{\frac{l}{g}}$ or $\frac{4\pi^2 l}{T_1^2} = g$

$T_2 = 2\pi\sqrt{\frac{l}{g+a}}$ or $\frac{4\pi^2 l}{T_2^2} = g + a$

$T_3 = 2\pi\sqrt{\frac{l}{g-a}}$ or $\frac{4\pi^2 l}{T_3^2} = g - a$

$\therefore\ \frac{4\pi^2 l}{T_2^2} + \frac{4\pi^2 l}{T_3^2} = 2g$ where $g = \frac{4\pi^2 l}{T_1^2}$

Solving we get, $T_1 = \frac{\sqrt{2}T_2T_3}{\sqrt{T_2^2 + T_3^2}}$

23. (a) : Here, time for maximum displacement, $t = 0.17$ sec. Time period T for one vibration

$= 4t = 4 \times 0.17 = 0.68$ sec

Frequency $= \frac{1}{\text{time period } (T)} = \frac{1}{0.68} = 1.47$ Hz

24. (a) : Wavelength $\lambda = \frac{\text{velocity}}{\text{frequency}} = \frac{1200\ \text{m/s}}{300\ \text{Hz}} = 4$ m

The distance between a node and neighbouring antinode is $\frac{\lambda}{4} = 1$ m

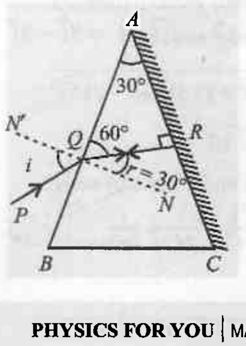
25. (b) Given : ${}^a\mu_w = \frac{4}{3}$; ${}^a\mu_g = \frac{3}{2}$; ${}^g\mu_w = ?$

${}^a\mu_w \times {}^w\mu_g = {}^a\mu_g$

or ${}^w\mu_g = \frac{{}^a\mu_g}{{}^a\mu_w} = \frac{3/2}{4/3} = \frac{9}{8}$

${}^g\mu_w = \frac{1}{{}^w\mu_g} = \frac{1}{(9/8)} = \frac{8}{9}$

26. (c) : It is clear from the figure that the ray will retrace the path when the refracted ray QR is incident normally on the polished surface AC. Thus angle of refraction $r = 30°$



$\mu = \sin i / \sin r$

$\therefore \sin i = \mu \sin r$

$\sin i = \sqrt{2} \times \sin 30° \; \sqrt{2} \times \frac{1}{2} = (1/\sqrt{2})$

$\therefore i = 45°$

27. (c) : Given: Separation between marks = d; Distance between paper and observer (D) = 50 m; Aperture of eye lens (a) = 2 mm = 2×10^{-3} m and mean wavelength of light (λ) = 5000 Å = 5000×10^{-10} m. The least distance between the marks to be seen separate,

$$d = \frac{1.22\lambda}{a} \times D = \frac{1.22 \times (5000 \times 10^{-10})}{2 \times 10^{-3}} \times 50$$

$= 15.25 \times 10^{-3}$ m $= 1.525$ cm

28. (d) : In case of diffraction at a single slit the position of minima is given by

$d \sin \theta = n\lambda$

If θ is small, $\sin\theta = \theta = \frac{y}{D}$

So the position of first minimum relative to centre will be given by

$d(y/D) = \lambda$, *i.e.*, $y = (D/d)\lambda$

Here, $D = 2$ m; $d = 1 \times 10^{-3}$ m and $\lambda = 6 \times 10^{-7}$ m

So $y = \frac{2 \times 6 \times 10^{-7}}{1 \times 10^{-3}} = 1.2$ mm

$\therefore$ Distance between first minima on either side of central maxima, $\Delta y = 2y = 2.4$ mm.

29. (d) :

30. (c) : Magnitude as well as polarities of charges at points A and C are same. Therefore forces at O, due to these charges cancel each other. Moreover, polarities of the charges at B and D are opposite; therefore force on charge kept at the centre is along the diagonal BD.

31. (d) : Given: Electrical potential

$V = -5x + 3y + \sqrt{15}z$

Electric field $\vec{E} = -\nabla V$

where $\nabla = \left[\frac{\partial}{\partial x}\vec{i} + \frac{\partial}{\partial y}\vec{j} + \frac{\partial}{\partial z}\vec{k}\right]$

$\therefore \vec{E} = -\left[\frac{\partial}{\partial x}\vec{i} + \frac{\partial}{\partial y}\vec{j} + \frac{\partial}{\partial z}\vec{k}\right](-5x + 3y + \sqrt{15}z)$

$= -\left[-5\vec{i} + 3\vec{j} + \sqrt{15}\vec{k}\right] = 5\vec{i} - 3\vec{i} - \sqrt{15}\vec{k}$

$|\vec{E}| = \sqrt{(5)^2 + (-3)^2 + (-\sqrt{15})^2}$

$= \sqrt{25 + 9 + 15} = 7$

32. (b) : C_1, C_2 and C_3 are in series

$$\frac{1}{C'} = \frac{1}{C} + \frac{1}{2C} + \frac{1}{3C}$$

or $\frac{1}{C'} = \frac{6+3+2}{6C} = \frac{11}{6C}$

$\therefore C' = \frac{6C}{11}$

Charge on each of the three capacitors in series is

$$Q' = \frac{6\,CV}{11}$$

Also charge on capacitor $C_4 = 4CV$

$\therefore$ Ratio $= \frac{Q'}{Q} = \frac{6CV}{11 \times 4CV} = \frac{3}{22}$

33. (c) : $0.6 = \frac{n \times 1.5}{n \times 0.5 + 20}$

Solving, we get $n = 10$

34. (b) : $\frac{V_1}{V_2} = \frac{l_1}{l_2} = \frac{ER_1/(R_1 + r)}{ER_2/(R_2 + r)} = \frac{R_1(R_2 + r)}{R_2(R_1 + r)}$

or $\frac{3}{2} = \frac{5(10 + r)}{10(5 + r)}$ or $r = 10\ \Omega$

35. (c) : $T_i = 620°C$, $T_n = 300°C$

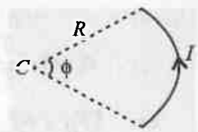
$T_n = \frac{T_i + T_c}{2}$

or $600 = 620 + T_c$

$\therefore T_c = -20°C$

36. (a) :

37. (b) : Magnetic field at the centre of a circular arc of radius R, carries current I and making an angle ϕ at the centre is given by



$B = \frac{\mu_0 I \phi}{4\pi R}$

In the given problem $\phi = \frac{\pi}{2}$

$\therefore B = \frac{\mu_0 I(\pi/2)}{4\pi R} = \frac{\mu_0 I}{8R}$

38. (a) : Efficiency of a transformer

$= \frac{\text{Output power }(P_o)}{\text{Input power}(P_i)} = \frac{V_S I_S}{V_P I_P}$

where V_S = Voltage across secondary

V_P = Voltage across primary

I_P = Current flowing in the primary

I_S = Current flowing in the secondary

$\therefore \frac{80}{100} = \frac{P_O}{4 \times 10^3}$

$\therefore P_O = \frac{16}{5} \times 10^3$ W $= 3200$ W

$\therefore I_S = \frac{P_O}{V_S} = \frac{3200}{200} = 16$ A

Also $P_i = I_P V_P$

or $I_P = \frac{P_i}{V_P} = \frac{4 \times 10^3 \text{ W}}{100 \text{ V}} = 40$ A

39. (c) : Self inductance $= \dfrac{\mu_0 N^2 A}{l}$

40. (b) : $v_A = \sqrt{2qV/m}, \quad v_B = \sqrt{2 \times 4qV/m}$

$\therefore \quad \dfrac{v_A}{v_B} = \dfrac{1}{2}$

41. (b) : For proton, $\lambda_1 = \dfrac{h}{\sqrt{2mE}}$

For photon, $\lambda_2 = \dfrac{hc}{E}$

$\therefore \quad \dfrac{\lambda_1}{\lambda_2} = \dfrac{h}{\sqrt{2mE}} \times \dfrac{E}{hc} \quad$ or $\quad \dfrac{\lambda_1}{\lambda_2} \propto \sqrt{E}$

42. (a) : According to Bohr's second postulate

Angular momentum $L = \dfrac{nh}{2\pi}$

Angular momentum is also called a moment of momentum.

For second orbit $n = 2$

$L = \dfrac{2h}{2\pi} = \dfrac{h}{\pi}$

43. (d) : $\omega = \dfrac{v}{r}$. Further $v \propto \dfrac{1}{n}$ and $r \propto n^2$,

hence $\omega \propto (1/n^3)$.

44. (b) : $\dfrac{1}{\lambda} = R\left[\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right]$

For shortest wavelength in Balmer series,

$n_1 = 2;\ n_2 = \infty$

$\dfrac{1}{\lambda} = R\left[\dfrac{1}{2^2} - \dfrac{1}{\infty^2}\right]$ or $\lambda = \dfrac{4}{R}$

For shortest wavelength in Brackett series

$\dfrac{1}{\lambda'} = R\left[\dfrac{1}{4^2} - \dfrac{1}{\infty^2}\right]$

$\lambda' = \dfrac{16}{R} = 4 \times \dfrac{4}{R} = 4\lambda$

45. (c) : According to Moseley's law

$\sqrt{\upsilon} = a(Z - b)$

Squaring both sides, $\upsilon = a^2(Z-b)^2$

or $\dfrac{c}{\lambda} = a^2(Z-b)^2$

Therefore, for two different elements, the ratio of wavelength is given by

$\dfrac{\lambda_1}{\lambda_2} = \dfrac{(Z_2-1)^2}{(Z_1-1)^2}$

$\lambda_1 = \lambda,\ Z_1 = 11,\ \lambda_2 = 4\lambda,\ Z_2 = ?$

$\therefore \quad \dfrac{\lambda}{4\lambda} = \dfrac{(Z_2-1)^2}{(11-1)^2}$; or $(Z_2 - 1)^2 = 25$; $\therefore \quad Z_2 = 6$

46. (d) : No. of half lives $= \dfrac{15}{5} = 3$

$\therefore \quad \dfrac{N}{N_0} = \left(\dfrac{1}{2}\right)^n = \left(\dfrac{1}{2}\right)^3 = \left(\dfrac{1}{8}\right)$; $\therefore \quad N = \dfrac{N_0}{8}$

47. (a) : $\alpha = 0.96,\ I_e = 7.2$ mA

$\alpha = \dfrac{I_c}{I_e}$ or $I_c = \alpha I_e$

$I_c = 0.96 \times 7.2$
$= 6.91$ mA

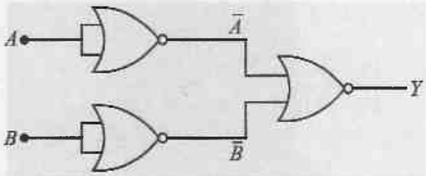
$I_e = I_c + I_b$

$I_b = I_e - I_c = 7.2 - 6.91 = 0.29$ mA

48. (c) : $E_\lambda = \dfrac{1240\ \text{eVnm}}{\lambda\ \text{nm}}$

$E_g = \dfrac{1240\ \text{eVnm}}{2480\ \text{nm}} = 0.5$ eV

49. (b) :



$Y = \overline{\overline{A} + \overline{B}} = \overline{\overline{A}} \cdot \overline{\overline{B}}$

[Using Boolean identity $\overline{A + B} = \overline{A} \cdot \overline{B}$]

$= A\,B$

50. (a) : Modulation index $= \dfrac{10}{20} = 0.5$

Practice Paper *for* CBSE Mains

Exam on 13 May 2007

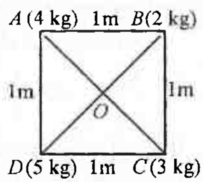
1.(a) Finding dimensions of resistance R and inductance L, speculate what physical quantities (L/R) and $(1/2)Li^2$ represents?

(b) If $|\vec{a}+\vec{b}| = |\vec{a}-\vec{b}|$, find the angle between vectors $\vec{a}$ and $\vec{b}$.

2.(a) When walking on ice, is it better to take short or long steps? Explain.

(b) A shell of mass 0.02 kg is fired by a gun of mass 100 kg. If the muzzle speed of the shell is 80 m s^{-1}, what is the recoil speed of the gun?

3.(a) Four particles of masses 4 kg, 2 kg, 3 kg and 5 kg are fixed at the four corners A, B, C and D of a square of each side 1 m. Calculate the moment of intertia of the system about an axis passing through the point of intersection of the diagonals and perpendicular to the plane of the square.



(b) If the radius of the earth is reduced to half of its present day value without change in its mass, what will be the length of the day?

4.(a) What will be the density of lead under a pressure of 20,000 N cm^{-2}? (Density of lead is 11.4 g cm^{-3} and the bulk modulus of lead is 0.80×10^{10} N m^{-2})

(b) Why is moisture retained longer in the soil if it is harrowed?

5.(a) A reversible engine converts one fifth of heat which it absorbs from source into work. When the temperature of the sink is reduced by 70 K, its efficiency is doubled. Calculate the temperature of the source and the sink.

(b) A particle is executing simple harmonic motion. If v_1 and v_2 are the speeds of the particle at distances x_1 and x_2 from the equilibrium position, show that the frequency of oscillations, $f = \frac{1}{2\pi}\left(\frac{v_1^2 - v_2^2}{x_2^2 - x_1^2}\right)^{1/2}$

6. (a) Two point charges one of +100 μC and another of −400 μC, are kept 30 cm apart. Find the points of zero potential on the line joining the two charges. (Assume the potential at infinity to be zero)

(b) A parallel plate capacitor with air between the plates has a capacitance of 8 pF (1 pF = 10^{-12} F). What will be the capacitance if the distance between the plates is reduced by half, and the space between them is filled with a substance of dielectric constant 6?

7.(a) 1 m long metallic wire is broken into two unequal parts P and Q. P part of the wire is uniformly extended into another wire R. Length of R is twice the length of P and the resistance of R is equal to that of Q. Find the ratio of the resistances of P and R and also the ratio of length of P and Q.

(b) A silver and a copper voltameter are connected in series with a 12.0 volt battery of negligible internal resistance. 0.806 g of silver is deposited in half an hour in the silver voltameter. Calculate

(i) magnitude of current flowing in the circuit,

(ii) mass of copper deposited in the copper voltameter during the same period.

(Given : ECE of silver = 1.12×10^{-8} kg C^{-1},
ECE of copper = 6.6×10^{-7} kg C^{-1}

8.(a) A 10 ohm coil of mean area 500 cm^2 and having 1000 turns is held perpendicular to a uniform field of 0.4 gauss. The coil is turned through 180° in (1/10) s. Calculate (i) the change in flux (ii) the average induced emf.

(b) A capacitor of capacitance 100 μF and a coil of resistance 50 Ω and inductance 0.5 H are connected in series with a 110 V, 50 Hz source. Calculate the r.m.s value of the current in the circuit.

9.(a) A photon and an electron both have energy of 100 eV. Which has the longer wavelength? Which has higher linear momentum?

(b) The half-life of radium is 1500 years. After how many years will one gram of the pure radium reduced to one milligram?

10.(a) A transistor has $\alpha = 0.95$. If the emitter current is 10 mA, what is the collector current, the base current and gain β?

(b) A glass prism of refracting angle 60° and refractive index 1.5, is completely immersed in water of refractive index 1.33. Calculate the angle of minimum deviation of the prism ($\sin^{-1} 0.56 = 34.3°$).

SOLUTIONS

1.(a) As $|\varepsilon| = L\frac{di}{dt}$ *i.e.*, $L = |\varepsilon|\frac{dt}{di}$

so $[L] = \left[\frac{W}{q}\right]\left[\frac{t}{i}\right] = \left[\frac{ML^2T^{-2}}{AT}\times\frac{T}{A}\right]$

i.e., $[L] = [ML^2\,T^{-2}\,A^{-2}]$ and as $V = IR$ *i.e.*, $R = V/I$

so $[R] = \left[\frac{W}{qI}\right] = \left[\frac{ML^2\,T^{-2}}{ATA}\right]$ *i.e.*, $[R] = [ML^2\,T^{-3}\,A^{-2}]$

so $\left[\frac{L}{R}\right] = \left[\frac{ML^2\,T^{-2}\,A^{-2}}{ML^2\,T^{-3}\,A^{-2}}\right] = \left[\frac{1}{T^{-1}}\right] = [T]$

and $\left[\frac{1}{2}Li^2\right] = [ML^2\,T^{-2}\,A^{-2}]\,[A^2] = [ML^2\,T^{-2}]$

Now as (L/R) has dimensions of time and so is called time constant of L - R circuit and $(1/2)\,Li^2$ has dimensions of work or energy, so it represents magnetic energy stored in a coil

(b) $|\vec{a}+\vec{b}| = \sqrt{a^2+b^2+2ab\cos\theta}$

$|\vec{a}-\vec{b}| = \sqrt{a^2+b^2-2ab\cos\theta}$

Given $|\vec{a}+\vec{b}| = |\vec{a}-\vec{b}|$ or $|\vec{a}+\vec{b}|^2 = |\vec{a}-\vec{b}|^2$

or $a^2+b^2+2ab\cos\theta = a^2+b^2-2ab\cos\theta$

or $4ab\cos\theta = 0$ or $\theta = 90°$

2.(a) Ice is almost frictionless. While walking, there must be sufficient friction to prevent slipping of feet. Frictional force depends on the normal reaction which depends on the inclination of the reaction of the ground to the vertical. If we take long steps the inclination of the reaction of the ground to the vertical becomes large and hence the frictional force is less. If we take short steps, the reaction remains close to the vertical. This helps to develop more frictional force on a slippery road and makes walking possible. This is why while walking on ice it is better to take short steps.

(b) : Given : $m = 0.02$ kg, $M = 100$ kg, $v = 80$ m s^{-1}

Let the recoil speed of the gun be V.

Then according to the principle of conservation of momentum, we get

$0 = mv + MV$ or $0 = 0.02 \times 80 + 100 \times V$

or $V = -\frac{0.02\times 80}{100}\,\text{m s}^{-1} = -0.016\ \text{m s}^{-1}$

–ve sign shows recoil speed of the gun.

3.(a) Given : $m_1 = 4$ kg, $m_2 = 2$ kg, $m_3 = 3$ kg, $m_4 = 5$ kg

$AB = BC = CD = DA = 1$ m

$\therefore\quad OA = OB = OC = OD = \frac{1}{\sqrt{2}}$ m

Moment of inertia of the system passing through O and perpendicular to the plane of the square,

$I = 4\,(OA)^2 + 2\,(OB)^2 + 3\,(OC)^2 + 5\,(OD)^2$

$$= 4\times\frac{1}{2}+2\times\frac{1}{2}+3\times\frac{1}{2}+5\times\frac{1}{2} = 7\ \text{kg m}^2$$

(b) : If M is the mass of earth, R its radius and ω its spin angular velocity, the angular momentum of earth will be $L_1 = I\omega = \frac{2}{5}MR^2\omega$ ...(i)

Now when its radius becomes half without change in its mass and ω' its spin angular velocity, the new angular momentum

$$L_2 = I'\omega' = \frac{2}{5}M(R/2)^2\omega' \quad \text{...(ii)}$$

As no external torque is acting, angular momentum must be conserved, *i.e.*, $L_1 = L_2$

From (i) and (ii), we get

$\therefore\quad \frac{2}{5}MR^2\omega = \frac{1}{4}\times\frac{2}{5}MR^2\omega'$, *i.e.*, $\omega' = 4\omega$

i.e., angular velocity will become 4 times of its initial value so

$\frac{T'}{T} = \frac{\omega}{\omega'} = \frac{1}{4}$ $\left[\text{as } T \propto \frac{1}{\omega}\right]$

or $T' = \frac{T}{4} = \frac{24}{4} = 6$ hour

4.(a) The bulk modulus of lead is given by, $K = \frac{\Delta P\cdot V}{\Delta V}$

Here, $K = 0.80 \times 10^{10}\ \text{N m}^{-2} = \dfrac{0.80\times10^{10}}{10^4}\ \text{N cm}^{-2}$

$$\Delta P = 20{,}000\ \text{N cm}^{-2} \quad \therefore \quad \frac{\Delta V}{V} = \frac{\Delta P}{K}$$

$$= \frac{20000\times10^4}{0.80\times10^{10}} = \frac{1}{40} \quad \text{or} \quad \Delta V = \frac{V}{40}$$

$\therefore$ New volume, $V' = V - \Delta V = V - \dfrac{V}{40} = \dfrac{39V}{40}$

Since the mass of lead will remain the same, we have

$$V\rho = V'\rho'$$

$\therefore$ New density, $\rho' = \dfrac{V\rho}{V'}$

$$= \frac{V\times11.4\times40}{39V} = 11.7\ \text{g cm}^{-3}$$

(b) When the soil is not harrowed, there are large capillaries in it. Water in the soil rise up the capillary holes to the surface from where it evaporates continuously. Thus the soil continuously loses water. When harrowed, all these capillaries are destroyed, and so capillary suction stops altogether. Thus, water is retained longer in the soil.

5.(a) According to the question,

$$W = \frac{1}{5}Q_1$$

Hence, $Q_2 = Q_1 - W = Q_1 - \dfrac{1}{5}Q_1 = \dfrac{4}{5}Q_1$

$$\therefore \frac{Q_2}{Q_1} = \frac{4}{5} \qquad \therefore \frac{T_2}{T_1} = \frac{Q_2}{Q_1} = \frac{4}{5} \qquad \text{...(i)}$$

Efficiency, $\eta = 1 - \dfrac{T_2}{T_1} = 1 - \dfrac{4}{5} = \dfrac{1}{5}$

On reducing the temperature of the sink by 70 K,

$$\text{Efficiency} = 2\eta = 1 - \frac{T_2 - 70}{T_1}$$

or $\quad 2\times\dfrac{1}{5} = 1 - \dfrac{T_2}{T_1} + \dfrac{70}{T_1} = 1 - \dfrac{4}{5} + \dfrac{70}{T_1}$

[using equation (i)]

or $\quad \dfrac{2}{5} = \dfrac{1}{5} + \dfrac{70}{T_1}$

Solving, $T_1 = 350$ K

From equation (i), $T_2 = \dfrac{4}{5}T_1 = \dfrac{4}{5}\times350 = 280\ \text{K}$

(b) The displacement of a particle executing simple harmonic motion is given by,

$$x = a\cos\omega t$$

$\therefore$ Velocity, $v = \dfrac{dx}{dt} = -a\omega\sin\omega t$

or $\quad v^2 = a^2\omega^2\sin^2\omega t = a^2\omega^2(1-\cos^2\omega t)$

$$= a^2\omega^2\left(1 - \frac{x^2}{a^2}\right) = \omega^2(a^2 - x^2)$$

Hence, $v_1^2 = \omega^2(a^2 - x_1^2)$ and $v_2^2 = \omega^2(a^2 - x_2^2)$

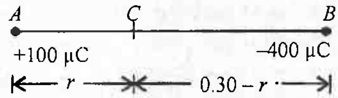
Subtracting the two, $v_1^2 - v_2^2 = \omega^2(x_2^2 - x_1^2)$

or $\quad \omega^2 = \dfrac{v_1^2 - v_2^2}{x_2^2 - x_1^2}$ or $\omega = \left(\dfrac{v_1^2 - v_2^2}{x_2^2 - x_1^2}\right)^{\frac{1}{2}}$

But $\omega = 2\pi f$

$\therefore \quad 2\pi f = \left(\dfrac{v_1^2 - v_2^2}{x_2^2 - x_1^2}\right)^{\frac{1}{2}}$ or $f = \dfrac{1}{2\pi}\left(\dfrac{v_1^2 - v_2^2}{x_2^2 - x_1^2}\right)^{\frac{1}{2}}$

6. **(a) :** As shown in figure, let the two charges be placed 30 cm (or 0.30 m) apart at points A and B. Let C be the point of zero potential on the line AB.



Potential at C due to two charges will be,

$$V = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1}{r_1} + \frac{q_2}{r_2}\right] = \frac{1}{4\pi\varepsilon_0}\left[\frac{100\times10^{-6}}{r} - \frac{400\times10^{-6}}{0.30-r}\right]$$

Since potential at C is zero, hence $V = 0$

or $\quad \dfrac{1}{4\pi\varepsilon_0}\left[\dfrac{100\times10^{-6}}{r} - \dfrac{400\times10^{-6}}{0.30-r}\right] = 0$

or $\quad \dfrac{1}{r} - \dfrac{4}{0.30-r} = 0$ or $4r = 0.30 - r$ or $5r = 0.30$

or $\quad r = \dfrac{0.30}{5} = 0.06\ \text{m} = 6\ \text{cm}$

Hence the point of zero potential lies at a distance of 6 cm from the charge of +100 μC on the line joining the two charges.

(b) : The capacitance of a parallel plate capacitor is given by,

$$C = \frac{\varepsilon_0 A}{d} \qquad \text{...(i)}$$

Now, the distance between the plates (d) is reduced by half $\left(\dfrac{d}{2}\right)$ and the space between them is filled with a substance of dielectric constant (K), new capacitance is given by,

$$C' = \frac{K\varepsilon_0 A}{d/2} = \frac{2K\varepsilon_0 A}{d} = 2KC$$

[Using equation (i)]

Here $K = 6$

$C = 8\text{ pF} = 8 \times 10^{-12}\text{ F}$

Hence. $C' = 2 \times 6 \times 8 \times 10^{-12}\text{ F} = 96 \times 10^{-12}\text{ F} = 96\text{ pF}$

7.(a) Let the length of piece P be L then of Q will $(1-L)$

So that, $R_P = \rho\frac{L}{S}$ and $R_Q = \rho\frac{(1-L)}{S}$

Now when part P is extended into another wire R of length twice of P, *i.e.*, $2L$ its resistance will be

$$R_R = \rho\frac{(2L)}{(S/2)} = 4\rho\frac{L}{S} \text{ [as } SL = 2L \times S'\text{]}$$

According to given problem

$$R_R = R_Q \quad i.e., \quad 4\rho\frac{L}{S} = \rho\frac{(1-L)}{S} \quad i.e., \ L = 0.2\text{ m}$$

So, $\frac{R_P}{R_R} = \frac{\rho(L/S)}{4\rho(L/S)} = \frac{1}{4}$ and $\frac{L_P}{L_Q} = \frac{L}{(1-L)} = \frac{0.2}{(1-0.2)} = \frac{1}{4}$

(b) Given : $m_1 = 0.806\text{ g} = 0.806 \times 10^{-3}\text{ kg}$

$t = 30\text{ min} = 30 \times 60\text{ s}$

$Z_1 = 1.12 \times 10^{-8}\text{ kg C}^{-1}$, $Z_2 = 6.6 \times 10^{-7}\text{ kg C}^{-1}$

(i) According to Faraday's first law of electrolysis, $m_1 = Z_1 It$

or $I = \frac{m_1}{Z_1 t} = \frac{0.806 \times 10^{-3}}{1.12 \times 10^{-8} \times 30 \times 60} = 40\text{ A}$

(ii) According to Faraday's second law of electrolysis,

$$\frac{m_1}{m_2} = \frac{Z_1}{Z_2}$$

or $m_2 = m_1 \times \frac{Z_2}{Z_1} = \frac{0.806 \times 10^{-3} \times 6.6 \times 10^{-7}}{1.12 \times 10^{-8}}\text{ kg}$

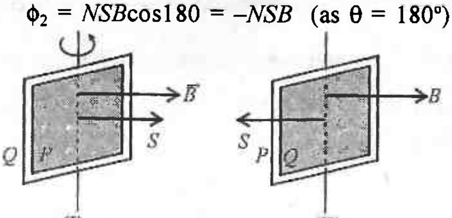
$= 47.5 \times 10^{-3}\text{ kg} = 47.5\text{ g}$

8.(a) (i) When the plane of a coil is perpendicular to the field as shown in figure (I) the angle between area $\vec{S}$ and field $\vec{B}$ is 0°. So the flux linked with the coil,

$\phi_1 = NBS\cos\theta = NSB\cos 0 = NSB$ [as $\theta = 0$]

When the coil is turned through 180° as shown in figure, (II) the flux linked with the coil will be

$\phi_2 = NSB\cos 180 = -NSB$ (as $\theta = 180°$)



(I) (II)

So change in flux,

$\Delta\phi = \phi_2 - \phi_1 = -NSB - NSB = -2NSB$

i.e., $|\Delta\phi| = 2 \times 10^3 \times (500 \times 10^{-4}) \times (0.4 \times 10^{-4}) = 4\text{ mWb}$

(ii) As in turning through 180°, *i.e.*, in change of flux $\Delta\phi$, the coil takes (1/10)s,

$$|\varepsilon_{av}| = \frac{|\Delta\phi|}{\Delta t} = \frac{2NSB}{\Delta t} = \frac{4 \times 10^{-3}}{10^{-1}} = 40\text{ mV}$$

(b) Given : $C = 100\ \mu\text{F} = 100 \times 10^{-6}\text{ F}$

$R = 50\ \Omega$, $L = 0.5\text{ H}$, $V_{rms} = 110\text{ V}$, $f = 50\text{ Hz}$

The impedance of LCR circuit is given by

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{R^2 + \left(2\pi fL - \frac{1}{2\pi fC}\right)^2}$$

$$= \sqrt{(50)^2 + \left(2 \times 3.14 \times 50 \times 0.5 - \frac{1}{2 \times 3.14 \times 50 \times 10^{-4}}\right)^2}$$

$$= \sqrt{(50)^2 + (157 - 31.85)^2} = \sqrt{2500 + 15662.5}$$

$= 134.77\ \Omega$

$\therefore$ r.m.s value of the current in the circuit is given by

$$I_{rms} = \frac{V_{rms}}{Z} = \frac{110}{134.77} = 0.816\text{ A.}$$

9. **(a)** : For photon $E = h\upsilon = \frac{hc}{\lambda}$

$$\therefore \lambda = \frac{hc}{E} = \frac{12400\text{ (eV.Å)}}{E\text{ (eV)}} = \frac{12400}{100\text{ eV}}\text{(eV. Å)} = 124\text{ Å}$$

For electron $p = h/\lambda$

$\Rightarrow \sqrt{2mE} = h/\lambda$ $\quad (\because E = p^2/2m)$

$\therefore \lambda = h/\sqrt{2mE}$

$= 6.6 \times 10^{-34}/\sqrt{2 \times 9 \times 10^{-31} \times 100 \times 1.6 \times 10^{-19}}$

$= 1.23\text{ Å}$

So the photon has a longer wavelength.

Momentum of photon

$= h\upsilon/c = h/\lambda$

$= 6.6 \times 10^{-34}/124 \times 10^{-10}$

$= 0.053 \times 10^{-24}\text{ kg m s}^{-1}$

Momentum of electron

$$= \frac{h}{\lambda} = \frac{6.6 \times 10^{-34}}{1.23 \times 10^{-10}} = 5.4 \times 10^{-24}\text{ kg m s}^{-1}$$

So the electron has greater momentum.

(b) $N = N_0 e^{-\lambda t}$ or $\frac{N}{N_0} = e^{-\lambda t}$

or $\log_e \frac{N}{N_0} = -\lambda t$ or $2.303 \log_{10} \frac{N}{N_0} = -\lambda t$

or $\quad t = -\dfrac{2.303\log_{10}\dfrac{N}{N_0}}{\lambda}$

But $\quad \lambda = \dfrac{0.693}{T_{1/2}} \quad \therefore \quad t = \dfrac{2.303\,T_{1/2}\log_{10}\dfrac{N_0}{N}}{0.693}$

Given : $N_0 = 1$ g

$\therefore \quad N = 1\text{ g} - 10^{-3}\text{ g} = (1 - 10^{-3})\text{g} = 0.999\text{ g}$

$\therefore \quad t = \dfrac{2.303 \times 1500 \times \log\dfrac{1}{0.999}}{0.693}$ year

$= \dfrac{2.303 \times 1500 \times 0.0004}{0.693} = 1.99$ year

10. (a) : Given : $\alpha = 0.95$, $I_E = 10$ mA

Now, $\alpha = \dfrac{I_C}{I_E}$ or $I_C = \alpha I_E = 0.95 \times 10 = 9.5$ mA

Since, $I_E = I_B + I_C \;\therefore\; I_B = I_E - I_C = 10 - 9.5 = 0.5$ mA

And $\beta = \dfrac{\alpha}{1-\alpha} = \dfrac{0.95}{1-0.95} = 19$

(b) : Given : $A = 60°$, ${}^a\mu_g = 1.5$, ${}^a\mu_w = 1.33$

Now $\quad {}^w\mu_g = \dfrac{{}^a\mu_g}{{}^a\mu_w} = \dfrac{1.5}{1.33} = 1.13$

Refractive index is given by,

$${}^w\mu_g = \frac{\sin\left(\dfrac{A+\delta_m}{2}\right)}{\sin\left(\dfrac{A}{2}\right)}$$

or $\quad 1.13 = \dfrac{\sin\left(\dfrac{A+\delta_m}{2}\right)}{\sin\left(\dfrac{60°}{2}\right)} = \dfrac{\sin\left(\dfrac{A+\delta_m}{2}\right)}{\dfrac{1}{2}}$

or $\quad \dfrac{1}{2} \times 1.13 = \sin\left(\dfrac{A+\delta_m}{2}\right)$

or $\quad \sin\left(\dfrac{A+\delta_m}{2}\right) = \dfrac{1}{2} \times 1.13 = 0.56 = \sin 34.3°$

or $\quad \dfrac{A+\delta_m}{2} = 34.3°$ or $\quad A + \delta_m = 68.6°$

or $\quad \delta_m = 68.6° - A = 68.6° - 60° = 8.6°$

SOLVED PAPER

CBSE-PMT (Prelims) - 2007

1. The primary and secondary coils of a transformer have 50 and 1500 turns respectively. If the magnetic flux ϕ linked with the primary coil is given by $\phi = \phi_0 + 4t$, where ϕ is in webers, t is time in seconds and ϕ_0 is a constant, the output voltage across the secondary coil is
(a) 120 volts (b) 220 volts
(c) 30 volts (d) 90 volts.

2. A beam of electron passes undeflected through mutually perpendicular electric and magnetic fields. If the electric field is switched off, and the same magnetic field is maintained, the electrons move
(a) in a circular orbit (b) along a parabolic path
(c) along a straight line (d) in an elliptical orbit.

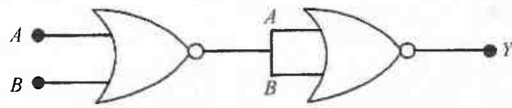
3. The position x of a particle with respect to time t along x-axis is given by $x = 9t^2 - t^3$ where x is in metres and t in second. What will be the position of this particle when it achieves maximum speed along the $+x$ direction?
(a) 54 m (b) 81 m (c) 24 m (d) 32 m.

4. A particle starting from the origin (0, 0) moves in a straight line in the (x, y) plane. Its coordinates at a later time are $(\sqrt{3}, 3)$. The path of the particle makes with the x-axis an angle of
(a) 45° (b) 60° (c) 0° (d) 30°.

5. A car moves from X to Y with a uniform speed v_u and returns to Y with a uniform speed v_d. The average speed for this round trip is
(a) $\sqrt{v_u v_d}$ (b) $\dfrac{v_d v_u}{v_d + v_u}$
(c) $\dfrac{v_u + v_d}{2}$ (d) $\dfrac{2v_d v_u}{v_d + v_u}$.

6. Two radioactive substances A and B have decay constants 5λ and λ respectively. At $t = 0$ they have the same number of nuclei. The ratio of number of nuclei of A to those of B will be $(1/e)^2$ after a time interval
(a) 4λ (b) 2λ (c) $1/2\lambda$ (d) $1/4\lambda$.

7. In the following circuit, the output Y for all possible inputs A and B is expressed by the truth table.



(a)

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

(b)

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

(c)

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

(d)

A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

8. In a radioactive decay process, the negatively charged emitted β-particles are
(a) the electrons produced as a result of the decay of neutrons inside the nucleus
(b) the electrons produced as a result of collisions between atoms
(c) the electrons orbiting around the nucleus
(d) the electrons present inside the nucleus.

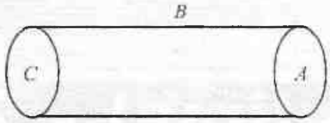
9. The phase difference between the instantaneous velocity and acceleration of a particle executing simple harmonic motion is
(a) π (b) 0.707π (c) zero (d) 0.5π.

10. In a mass spectrometer used for measuring the masses of ions, the ions are initially accelerated by an electric potential V and then made to describe semicircular paths of radius R using a magnetic field B. If V and B are kept constant, the ratio $\left(\dfrac{\text{charge on the ion}}{\text{mass of the ion}}\right)$ will be proportional to
(a) $1/R^2$ (b) R^2 (c) R (d) $1/R$.

11. A wheel has angular acceleration of 3.0 rad/sec^2 and an initial angular speed of 2.00 rad/sec. In a time of 2 sec it has rotated through an angle (in radian) of
(a) 10 (b) 12 (c) 4 (d) 6.

12. A hollow cylinder has a charge q coulomb within

it. If ϕ is the electric flux in units of voltmeter associated with the curved surface B, the flux linked with the plane surface A in units of voltmeter will be



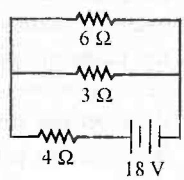
(a) $\dfrac{q}{2\varepsilon_0}$ (b) $\dfrac{\phi}{3}$

(c) $\dfrac{q}{\varepsilon_0}-\varphi$ (d) $\dfrac{1}{2}\left(\dfrac{q}{\varepsilon_0}-\phi\right)$.

13. The frequency of a light wave in a material is 2×10^{14} Hz and wavelength is 5000 Å. The refractive index of material will be
(a) 1.50 (b) 3.00 (c) 1.33 (d) 1.40

14. A nucleus ${}^{A}_{Z}X$ has mass represented by $M(A, Z)$. If M_p and M_n denote the mass of proton and neutron respectively and B.E. the binding energy in MeV, then
(a) B.E. = $[ZM_p + (A - Z)M_n - M(A, Z)]c^2$
(b) B.E. = $[ZM_p + AM_n - M(A, Z)]c^2$
(c) B.E. = $M(A, Z) - ZM_p - (A - Z)M_n$
(d) B.E. = $[M(A, Z) - ZM_p - (A - Z)M_n]c^2$.

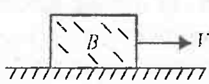
15. The total power dissipated in watts in the circuit shown here is



(a) 40 (b) 54
(c) 4 (d) 16.

16. If the nucleus ${}^{27}_{13}\text{Al}$ has a nuclear radius of about 3.6 fm, then ${}^{125}_{32}\text{Te}$ would have its radius approximately as
(a) 9.6 fm (b) 12.0 fm (c) 4.8 fm (d) 6.0 fm.

17. A block B is pushed momentarily along a horizontal surface with an initial velocity V. If μ is the coefficient of sliding friction between B and the surface, block B will come to rest after a time



(a) $g\mu/V$ (b) g/V (c) V/g (d) $V/(g\mu)$.

18. A particle moving along x-axis has acceleration f, at time t, given by $f = f_0\left(1-\dfrac{t}{T}\right)$, where f_0 and T are constants. The particle at $t = 0$ has zero velocity. In the time interval between $t = 0$ and the instant when $f = 0$, the particle's velocity (v_x) is

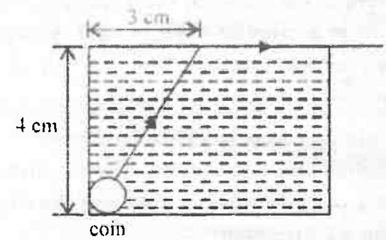
(a) $\dfrac{1}{2}f_0T^2$ (b) f_0T^2 (c) $\dfrac{1}{2}f_0T$ (d) f_0T.

19. A common emitter amplifier has a voltage gain of 50, an input impedance of 100 Ω and an output impedence of 200 Ω. The power gain of the amplifier is
(a) 1000 (b) 1250 (c) 100 (d) 500.

20. Three resistances P, Q, R each of 2 Ω and an unknown resistances S form the four arms of a Wheatstone bridge circuit. When a resistance of 6 Ω is connected in parallel to S the bridge gets balanced. What is the value of S?
(a) 3 Ω (b) 6 Ω (c) 1 Ω (d) 2 Ω.

21. A steady current of 1.5 amp flows through a copper voltameter for 10 minutes. If the electrochemical equivalent of copper is 30×10^{-5} g coulomb^{-1}, the mass of copper deposited on the electrode will be
(a) 0.50 g (b) 0.67 g (c) 0.27 g (d) 0.40 g.

22. A small coin is resting on the bottom of a beaker filled with liquid. A ray of light from the coin travels upto the surface of the liquid and moves along its surface. How fast is the light travelling in the liquid?

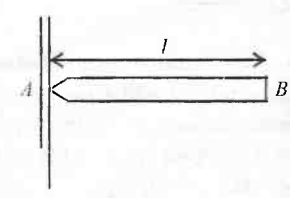


(a) 2.4×10^8 m/s (b) 3.0×10^8 m/s
(c) 1.2×10^8 m/s (d) 1.8×10^8 m/s.

23. A transformer is used to light a 100 W and 110 V lamp from a 220 V mains. If the main current is 0.5 amp, the efficiency of the transformer is approximately
(a) 50% (b) 90% (c) 10% (d) 30%.

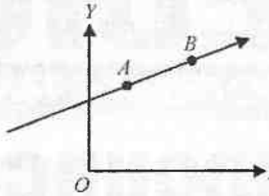
24. Dimensions of resistance in an electrical circuit, in terms of dimension of mass M, of length L, of time T and of current I, would be
(a) ML^2T^{-2} (b) $ML^2T^{-1}I^{-1}$
(c) $ML^2T^{-3}I^{-2}$ (d) $ML^2T^{-3}I^{-1}$.

25. A uniform rod AB of length l and mass m is free to rotate about point A. The rod is released from rest in the horizontal position. Given that the moment of inertia of the rod about A is $ml^2/3$, the initial angular acceleration of the rod will be



(a) $\frac{mgl}{2}$ (b) $\frac{3}{2}gl$ (c) $\frac{3g}{2l}$ (d) $\frac{2g}{3l}$.

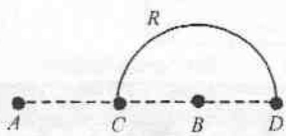
26. A particle of mass m moves in the XY plane with a velocity v along the straight line AB. If the angular momentum of the particle with respect to origin O is L_A when it is at A and L_B when it is at B, then



(a) $L_A = L_B$
(b) the relationship between L_A and L_B depends upon the slope of the line AB
(c) $L_A < L_B$ (d) $L_A > L_B$.

27. The particle executing simple harmonic motion has a kinetic energy $K_0 \cos^2 \omega t$. The maximum values of the potential energy and the total energy are respectively
(a) $K_0/2$ and K_0 (b) K_0 and $2K_0$
(c) K_0 and K_0 (d) 0 and $2K_0$.

28. Charges $+q$ and $-q$ are placed at points A and B respectively which are a distance $2L$ apart, C is the midpoint between A and B. The work done in moving a charge $+O$ along the semicircle CRD is



(a) $\frac{qQ}{2\pi\varepsilon_0 L}$ (b) $\frac{qQ}{6\pi\varepsilon_0 L}$

(c) $-\frac{qQ}{6\pi\varepsilon_0 L}$ (d) $\frac{qQ}{4\pi\varepsilon_0 L}$.

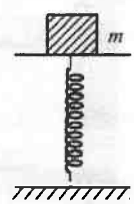
29. Monochromatic light of frequency 6.0×10^{14} Hz is produced by a laser. The power emitted is 2×10^{-3} W. The number of photons emitted, on the average, by the source per second is
(a) 5×10^{16} (b) 5×10^{17}
(c) 5×10^{14} (d) 5×10^{15}.

30. Three point charges $+q$, $-2q$ and $+q$ are placed at points $(x = 0, y = a, z = 0)$, $(x = 0, y = 0, z = 0)$ and $(x = a, y = 0, z = 0)$ respectively. The magnitude and direction of the electric dipole moment vector of this charge assembly are
(a) $\sqrt{2}qa$ along the line joining points $(x = 0, y = 0, z = 0)$ and $(x = a, y = a, z = 0)$
(b) qa along the line joining points $(x = 0, y = 0, z = 0)$ and $(x = a, y = a, z = 0)$
(c) $\sqrt{2}qa$ along $+x$ direction
(d) $\sqrt{2}qa$ along $+y$ direction.

31. Two satellites of earth, S_1 and S_2 are moving in the same orbit. The mass of S_1 is four times the mass of S_2. Which one of the following statements is true?
(a) The potential energies of earth and satellite in the two cases are equal.
(b) S_1 and S_2 are moving with the same speed.
(c) The kinetic energies of the two satellites are equal.
(d) The time period of S_1 is four times that of S_2.

32. $\vec{A}$ and $\vec{B}$ are two vectors and θ is the angle between them, if $|\vec{A} \times \vec{B}| = \sqrt{3}(\vec{A} \cdot \vec{B})$, the value of θ is
(a) 45° (b) 30° (c) 90° (d) 60°.

33. A mass of 2.0 kg is put on a flat pan attached to a vertical spring fixed on the ground as shown in the figure. The mass of the spring and the pan is negligible. When pressed slightly and released the mass executes a simple harmonic motion. The spring constant is 200 N/m. What should be the minimum amplitude of the motion so that the mass gets detached from the pan (take $g = 10$ m/s^2).



(a) 10.0 cm
(b) any value less than 12.0 cm
(c) 4.0 cm (d) 8.0 cm.

34. A charged particle (charge q) is moving in a circle of radius R with uniform speed v. The associated magnetic moment μ is given by
(a) qvR^2 (b) $qvR^2/2$ (c) qvR (d) $qvR/2$.

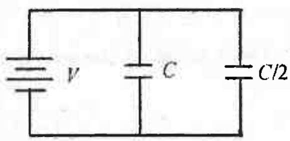
35. The total energy of electron in the ground state of hydrogen atom is -13.6 eV. The kinetic energy of an electron in the first excited state is
(a) 6.8 eV (b) 13.6 eV
(c) 1.7 eV (d) 3.4 eV.

36. A 5 watt source emits monochromatic light of wavelength 5000 Å. When placed 0.5 m away, it liberates photoelectrons from a photosensitive metallic surface. When the source is moved to a distance of 1.0 m, the number of photoelectrons liberated will be reduced by a factor of
(a) 8 (b) 16 (c) 2 (d) 4.

37. A particle executes simple harmonic oscillation with an amplitude a. The period of oscillation is T. The minimum time taken by the particle to travel half of the amplitude from the equilibrium position is
(a) $T/8$ (b) $T/12$ (c) $T/2$ (d) $T/4$.

38. For a cubic crystal structure which one of the following relations indicating the cell characteristics is correct?
(a) $a \neq b \neq c$ and $\alpha = \beta = \gamma = 90°$
(b) $a = b = c$ and $\alpha \neq \beta \neq \gamma = 90°$
(c) $a = b = c$ and $\alpha = \beta = \gamma = 90°$
(d) $a \neq b \neq c$ and $\alpha \neq \beta$ and $\gamma \neq 90°$.

39. Two condensers, one of capacity C and other other of capacity $C/2$ are connected to a V-volt battery, as shown.



The work done in charging fully both the condensers is
(a) $\frac{1}{4}CV^2$ (b) $\frac{3}{4}CV^2$ (c) $\frac{1}{2}CV^2$ (d) $2CV^2$.

40. A black body is at 727°C. It emits energy at a rate which is proportional to
(a) $(1000)^4$ (b) $(1000)^2$ (c) $(727)^4$ (d) $(727)^2$.

41. The resistance of an ammeter is 13 Ω and its scale is graduated for a current upto 100 amps. After an additional shunt has been connected to this ammeter it becomes possible to measure currents upto 750 amperes by this meter. The value of shunt-resistance is
(a) 2 Ω (b) 0.2 Ω (c) 2 kΩ (d) 20 Ω.

42. An engine has an efficiency of 1/6. When the temperature of sink is reduced by 62°C, its efficiency is doubled. Temperatures of the source is
(a) 37°C (b) 62°C (c) 99°C (d) 124°C.

43. The electric and magnetic field of an electromagnetic wave are
(a) in opposite phase and perpendicular to each other
(b) in opposite phase and parallel to each other
(c) in phase and perpendicular to each other
(d) in phase and parallel to each other.

44. What is the value of inductance L for which the current is maximum in a series LCR circuit with $C = 10\ \mu F$ and $\omega = 1000\ s^{-1}$?
(a) 1 mH
(b) cannot be calculated unless R is known
(c) 10 mH (d) 100 mH.

45. Nickel shows ferromagnetic property at room temperature. If the temperature is increased beyond Curie temperature, then it will show
(a) anti ferromagnetism (b) no magnetic property
(c) diamagnetism (d) paramagnetism.

46. A vertical spring with force constant k is fixed on a table. A ball of mass m at a height h above the free upper end of the spring falls vertically on the spring so that the spring is compressed by a distance d. The net work done in the process is

(a) $mg(h+d) - \frac{1}{2}kd^2$ (b) $mg(h-d) - \frac{1}{2}kd^2$

(c) $mg(h-d) + \frac{1}{2}kd^2$ (d) $mg(h+d) + \frac{1}{2}kd^2$.

47. Under the influence of a uniform magnetic field a charged particle is moving in a circle of radius R with constant speed v. The time period of the motion
(a) depends on both R and v
(b) is independent of both R and v
(c) depends on R and not on v
(d) depends on v and not on R.

48. If the cold junction of a thermo-couple is kept at 0°C and the hot junction is kept at T°C, then the relation between neutral temperature (T_n) and temperature of inversion (T_i) is
(a) $T_n = 2T_i$ (b) $T_n = T_i - T$
(c) $T_n = T_i + T$ (d) $T_n = T_i/2$.

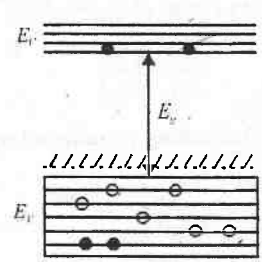
49. Assuming the sun to have a spherical outer surface of radius r, radiating like a black body at temperature t°C, the power received by a unit surface, (normal to the incident rays) at a distance R from the centre of the sun is

(a) $\frac{r^2\sigma(t+273)^4}{4\pi R^2}$ (b) $\frac{16\pi^2 r^2 \sigma t^4}{R^2}$

(c) $\frac{r^2\sigma(t+273)^4}{R^2}$ (d) $\frac{4\pi r^2 \sigma t^4}{R^2}$

where σ is the Stefan's constant.

50. In the energy band diagram of a material shown below, the open circles and filled circles denote holes and electrons respectively. The material is



(a) an insulator
(b) a metal

(c) an n-type semiconductor
(d) a p-type semiconductor.

SOLUTIONS

1. (a) : Given : No. of turns across primary $N_p = 50$
Number of turns across secondary $N_s = 1500$
Magnetic flux linked with primary, $\phi = \phi_0 + 4t$

$\therefore$ Voltage across the primary, $V_p = \frac{d\phi}{dt} = \frac{d}{dt}(\phi_0 + 4t)$
$= 4$ volt.

Also, $\frac{V_s}{V_p} = \frac{N_s}{N_p}$

$\therefore \quad V_s = \left(\frac{1500}{50}\right) \times 4 = 120$ V.

2. (a) : Electron travelling in a magnetic field perpendicular to its velocity - circular path.

3. (a) : Given : $x = 9t^2 - t^3$ ... (i)

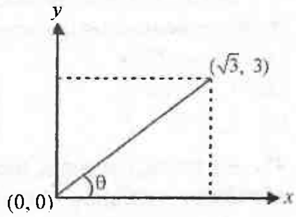
Speed $v = \frac{dx}{dt} = \frac{d}{dt}(9t^2 - t^3) = 18t - 3t^2$.

For maximum speed, $\frac{dv}{dt} = 0 \Rightarrow 18 - 6t = 0$

$\therefore \quad t = 3$ s.

$\therefore \quad x_{max} = 81$ m $- 27$ m $= 54$ m. (From $x = 9t^2 - t^3$).

4. (b) : Let θ be the angle which the particle makes with an x-axis. From figure,



$\tan\theta = \frac{3}{\sqrt{3}} = \sqrt{3}$

or, $\theta = \tan^{-1}(\sqrt{3}) = 60°$.

5. (d) : Average speed $= \frac{\text{total distance travelled}}{\text{total time taken}}$

$$= \frac{s+s}{t_1+t_2} = \frac{2s}{\frac{s}{v_u} + \frac{s}{v_d}} = \frac{2v_u v_d}{v_d + v_u}.$$

6. (c) : Given : $\lambda_A = 5\lambda$, $\lambda_B = \lambda$
At $t = 0$, $(N_0)_A = (N_0)_B$

$$\frac{N_A}{N_B} = \left(\frac{1}{e}\right)^2$$

According to radioactive decay, $\frac{N}{N_0} = e^{-\lambda t}$

$\therefore \quad \frac{N_A}{(N_0)_A} = e^{-\lambda_A t}$ ... (i)

$\frac{N_B}{(N_0)_B} = e^{-\lambda_B t}$ ... (ii)

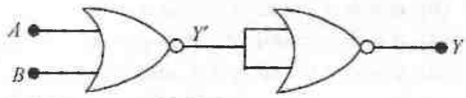
Divide (i) by (ii), we get

$\frac{N_A}{N_B} = e^{-(\lambda_A - \lambda_B)t}$ or, $\frac{N_A}{N_B} = e^{-(5\lambda - \lambda)t}$

or, $\left(\frac{1}{e}\right)^2 = e^{-4\lambda t}$ or, $\left(\frac{1}{e}\right)^2 = \left(\frac{1}{e}\right)^{4\lambda t}$

or, $4\lambda t = 2 \Rightarrow t = \frac{2}{4\lambda} = \frac{1}{2\lambda}$.

7. (c) :



$Y' = \overline{A+B}$ · $\quad Y = \overline{\overline{A+B}} = A+B$.

Truth table of the given circuit is given by

A	B	Y'	Y
0	0	1	0
0	1	0	1
1	0	0	1
1	1	0	1

8. (a) : In beta minus decay (β^-), a neutron is transformed into a proton and an electron is emitted with the nucleus along with an antineutrino.

$$n \rightarrow p + e^- + \nu$$

where $\bar{\nu}$ is the antineutrino.

9. (d) : Let $y = A\sin\omega t$

$$\frac{dy}{dt} = A\omega\cos\omega t = A\omega\sin\left(\omega t + \frac{\pi}{2}\right)$$

Acceleration $= -A\omega^2\sin\omega t$

The phase difference between acceleration and velocity is $\pi/2$.

10. (a) : In mass spectrometer when ions are accelerated through potential V, $\frac{1}{2}mv^2 = qV$ ... (i)

where m is the mass of ion, q is the charge of the ion. As the magnetic field curves the path of the ions in a semicircular orbit

$\therefore \quad Bqv = \frac{mv^2}{R} \Rightarrow v = \frac{BqR}{m}$ ... (ii)

Substituting (ii) in (i), we get

$\frac{1}{2}m\left[\frac{BqR}{m}\right]^2 = qV$ or, $\frac{q}{m} = \frac{2V}{B^2R^2}$

Since V, B are constants,

$\frac{q}{m} \propto \frac{1}{R^2}$ or, $\frac{\text{charge on the ion}}{\text{mass of the ion}} \propto \frac{1}{R^2}$.

11. (a) : Given: Angular acceleration, $\alpha = 3$ rad/sec^2
Initial angular velocity $\omega_i = 2$ rad/sec
Time $t = 2$ sec

Using, $\theta = \omega_i t + \frac{1}{2}\alpha t^2$

$\therefore \quad \theta = 2 \times 2 + \frac{1}{2} \times 3 \times 4 = 4 + 6 = 10$ radian.

12. (d) : Let ϕ_A, ϕ_B and ϕ_C are the electric flux linked with A, B and C.

According to Gauss theorem, $\phi_A + \phi_B + \phi_C = \frac{q}{\varepsilon_0}$

Since $\phi_A = \phi_C$,

$\therefore \quad 2\phi_A + \phi_B = \frac{q}{\varepsilon_0}$ or $2\phi_A = \frac{q}{\varepsilon_0} - \phi_B$

or, $2\phi_A = \frac{q}{\varepsilon_0} - \phi$ (Given $\phi_B = \phi$).

$\therefore \quad \phi_A = \frac{1}{2}\left(\frac{q}{\varepsilon_0} - \phi\right)$.

13. (b) : $\mu = \dfrac{\text{velocity of light in vacuum } (c)}{\text{velocity of light in medium } (v)}$

$\therefore \quad v = \upsilon\lambda = 2 \times 10^{14} \times 5000 \times 10^{-10}$

In the medium, $v = 10^8$ m/s

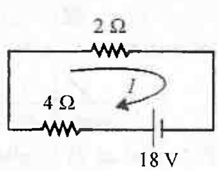
$\therefore \quad \mu = \frac{v_{vac}}{v_{med}} = \frac{3 \times 10^8}{10^8} = 3$.

14. (a)

15. (b) : In the given circuit 6 Ω and 3 Ω are in parallel, and hence its equivalent resistance is given by

$$\frac{1}{R_p} = \frac{1}{6} + \frac{1}{3} \quad \text{or} \quad R_p = 2\,\Omega.$$

The equivalent circuit diagram is given in figure.



Total current in the circuit,

$$I = \frac{18}{2+4} = 3\text{ A.}$$

Power in the circuit $= VI = 18 \times 3 = 54$ watt.

16. (d) : Nuclear radii $R = (R_0)A^{1/3}$
where A is the mass number.

$\therefore \quad \frac{R_{Te}}{R_{Al}} = \left(\frac{A_{Te}}{A_{Al}}\right)^{1/3} = \left(\frac{125}{27}\right)^{1/3} = \left(\frac{5}{3}\right)$

or, $R_{Te} = \frac{5}{3} \times R_{Al} = \frac{5}{3} \times 3.6 = 6$ fm. (Given $R_{Al} = 3.6$ fm)

17. (d) : Given $u = V$, final velocity $= 0$.
Using $v = u + at$

$\therefore \quad 0 = V - at$ or, $-a = \frac{0 - V}{t} = -\frac{V}{t}$

$f = \mu R = \mu mg$ (f is the force of friction)

$\therefore$ Retardation, $a = \mu g$

$\therefore \quad t = \frac{V}{a} = \frac{V}{\mu g}$.

18. (c) : Given : At time $t = 0$, velocity, $v = 0$.

Acceleration $f = f_0\left(1 - \frac{t}{T}\right)$

At $f = 0$, $\quad 0 = f_0\left(1 - \frac{t}{T}\right)$

Since f_0 is a constant, $\therefore \; 1 - \frac{t}{T} = 0$ or $t = T$.

Also, acceleration $f = \frac{dv}{dt}$

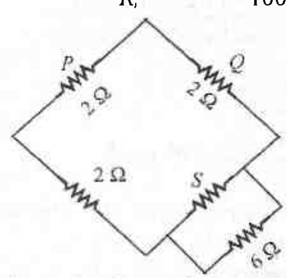
$$\therefore \quad \int_0^{v_x} dv = \int_{t=0}^{t=T} f\,dt = \int_0^T f_0\left(1 - \frac{t}{T}\right)dt$$

$$\therefore \quad v_x = \left[f_0 t - \frac{f_0 t^2}{2T}\right]_0^T = f_0 T - \frac{f_0 T^2}{2T} = \frac{1}{2} f_0 T.$$

19. Option not provided.
Given : Voltage gain $\beta = 50$
Output resistance $R_o = 200\,\Omega$
Input resistance $R_i = 100\,\Omega$

Power gain $= \beta^2 \times \frac{R_o}{R_i} = (50)^2 \times \frac{200}{100} = 5000$.

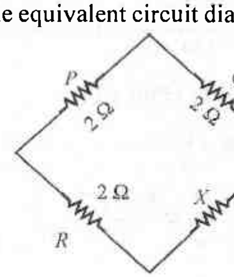
20. (a) :



Let X be the equivalent resistance between S and 6 Ω.

$$\therefore \quad \frac{1}{X} = \frac{1}{S} + \frac{1}{6} \qquad \text{... (i)}$$

Therefore, the equivalent circuit diagram drawn below.



For a balanced Wheatstone bridge, we get

$$\frac{P}{Q}=\frac{R}{X} \quad \text{or} \quad \frac{2}{2}=\frac{2}{X} \quad \Rightarrow \quad X=2\ \Omega.$$

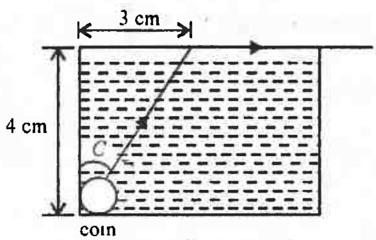
From eqn. (i), we get

$$\frac{1}{2}=\frac{1}{S}+\frac{1}{6} \quad \text{or,} \quad \frac{1}{S}=\frac{2}{6} \quad \text{or,} \quad S=3\ \Omega.$$

21. (c) : Given : I = 1.5 A, t = 10 min = 600 sec
$Z = 30 \times 10^{-5}$ g coulomb^{-1}.
According to Faraday, first law of electrolysis

$m = ZIt = 30 \times 10^{-5} \times 1.5 \times 600$
$= 0.27$ g.

22. (d) :



From figure, $\sin C = \frac{3}{\sqrt{(4)^2+(3)^2}} = \frac{3}{5}$

where C is the critical angle.

Also, $\sin C = {}^l\mu_a$

$$\sin C = \frac{1}{{}^a\mu_l} \quad \left[\text{since } {}^l\mu_a = \frac{1}{{}^a\mu_l}\right]$$

Also ${}^a\mu_l = \frac{\text{velocity of light in air } (c)}{\text{velocity of light in liquid } (v)}$

$$\therefore \quad \sin C = \frac{v}{c} = \frac{v}{3\times10^8}$$

or, $v = 3\times10^8 \times \frac{3}{5} = 1.8\times10^8\ \text{ms}^{-1}$.

23. (b) : Given : Output power P = 100 W
Voltage across primary V_p = 220 V
Current in the primary I_p = 0.5 A

Efficiency of a transformer $\eta = \frac{\text{output power}}{\text{input power}} \times 100$

$$= \frac{P}{V_p I_p}\times 100 = \frac{100}{220\times 0.5}\times 100 = 90\%.$$

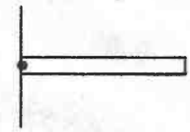
24. (c) : According to Ohm's law,

$$V = RI \quad \text{or} \quad R = \frac{V}{I}$$

Dimensions of $V = \frac{W}{q} = \frac{\text{ML}^2\text{T}^{-2}}{\text{IT}}$

$$\therefore \quad R = \frac{[\text{ML}^2\text{T}^{-2}/\text{IT}]}{\text{I}} = \text{ML}^2\text{T}^{-3}\text{I}^{-2}.$$

25. (c) : Torque about A,

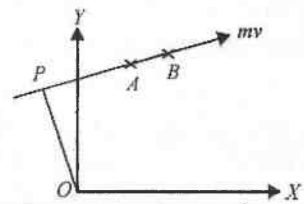


$$\tau = mg \times \frac{l}{2} = \frac{mgl}{2}$$

Also $\tau = I\alpha$

$\therefore$ Angular acceleration, $\alpha = \frac{\tau}{I} = \frac{mgl/2}{ml^2/3} = \frac{3}{2}\frac{g}{l}$.

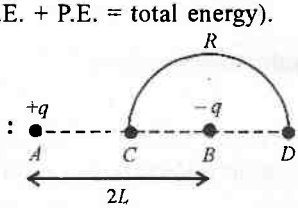
26. (a) :



Moment of momentum is angular momentum, OP is the same whether the mass is at A or B.
$\therefore \quad L_A = L_B$.

27. (c) : Kinetic energy + potential energy = total energy
When kinetic energy is maximum, potential energy is zero and vice versa.
$\therefore$ Maximum potential energy = total energy.
$0 + K_0 = K_0$
(K.E. + P.E. = total energy).

28. (c) :



From figure, $AC = L$, $BC = L$, $BD = BC = L$
$AD = AB + BD = 2L + L = 3L$
Potential at C is given by

$$V_C = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{AC}+\frac{(-q)}{BC}\right] = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{L}-\frac{q}{L}\right] = 0$$

Potential at D is given by

$$V_D = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{AD}+\frac{(-q)}{BD}\right] = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{3L}-\frac{q}{L}\right]$$
$$= \frac{1}{4\pi\varepsilon_0}\frac{q}{L}\left[\frac{1}{3}-1\right] = \frac{-q}{6\pi\varepsilon_0}.$$

Work done in moving charge $+Q$ along the semicircle CRD is given by

$$W = [V_D - V_C](+Q) = \left[\frac{-q}{6\pi\varepsilon_0} - 0\right](Q) = \frac{-qQ}{6\pi\varepsilon_0 L}$$

Comments : Potential at C is zero because the charges are equal and opposite and the distances are the same.

Potential at D due to $-q$ is greater than that at A $(+q)$, because D is closer to B. Therefore it is negative.

29. (d) : Power of monochromatic light beam is $P = Nh\upsilon$ where N is the number of photons emitted per second.

Power $P = 2 \times 10^{-3}$ W

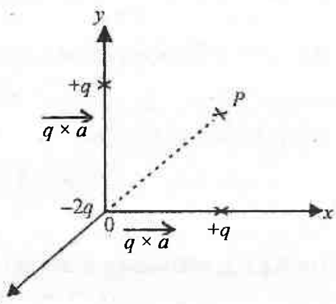
Energy of one photon $E = h\upsilon$

$$= 6.63 \times 10^{-34} \times 6 \times 10^{14} \text{ J}$$

Number of photons emitted per second, $N = P/E$

$$= \frac{2\times10^{-3}}{6.63\times10^{-34}\times6\times10^{14}} = 0.05\times10^{17} = 5\times10^{15}.$$

30. (a) : This consists of two dipoles, $-q$ and $+q$ with dipole moment along with the $+y$-direction and $-q$ and $+q$ along the x-direction.



$\therefore$ The resultant moment $= \sqrt{q^2a^2+q^2a^2} = \sqrt{2}qa.$

Along the direction 45° that is along OP where P is $(+a, +a, 0)$.

31. (b) : The satellite of mass m is moving in a circular orbit of radius r.

$\therefore$ Kinetic energy of a satellite, $K = \dfrac{GMm}{2r}$ ... (i)

Potential energy of a satellite, $U = \dfrac{-GMm}{r}$ ... (ii)

Orbital speed of satellite, $v = \sqrt{\dfrac{GM}{r}}$ ... (iii)

Time-period of satellite, $T = \left[\left(\dfrac{4\pi^2}{GM}\right)r^3\right]^{1/2}$ ... (iv)

Given $m_{S_1} = 4m_{S_2}$

Since M, r is same for both the satellites S_1 and S_2

$\therefore$ From equation (ii), we get $U \propto m$

$\therefore \quad \dfrac{U_{S_1}}{U_{S_2}} = \dfrac{m_{S_1}}{m_{S_2}} = 4 \qquad$ or, $U_{S_1} = 4U_{S_2}$.

Option (a) is wrong.

From (iii), since v is independent of the mass of a satellite, the orbital speed is same for both satellites S_1 and S_2. Hence option (b) is correct.

From (i), we get $K \propto m$

$\therefore \quad \dfrac{K_{S_1}}{K_{S_2}} = \dfrac{m_{S_1}}{m_{S_2}} = 4 \qquad$ or, $K_{S_1} = 4K_{S_2}$.

Hence option (c) is correct.

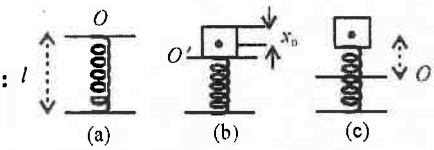
From (iv), since T is independent on the mass of a satellite, time period is same for both the satellites S_1 and S_2. Hence option (d) is wrong.

32. (d) : $|\vec{A}\times\vec{B}| = \sqrt{3}(\vec{A}\cdot\vec{B})$

$\therefore \quad AB\sin\theta = \sqrt{3}AB\cos\theta$

or, $\tan\theta = \sqrt{3}$ or, $\theta = \tan^{-1}\sqrt{3} = 60°$.

33. (a) :



The spring has a length l. Whem m is placed over it, the equilibrium position becomes O'.

If it is pressed from O' (the equilibrium position) to O'', $O'O''$ is the amplitude.

$$OO' = \frac{mg}{k} = \frac{2\times10}{200} = 0.10 \text{ m}.$$

$mg = kx_0$.

If the restoring force $mA\omega^2 > mg$, then the mass will move up with acceleration, detached from the pan.

i.e. $A > \dfrac{g}{k/m} \rightarrow A > \dfrac{20}{200} > 0.10$ m.

The amplitude > 10 cm.

i.e. the minimum is just greater than 10 cm.

(The actual compression will include x_0 also. But when talking of amplitude, it is always from the equilibrium position with respect to which the mass is oscillating.

34. (d) : Magnetic moment $\mu = IA$

Since $T = \dfrac{2\pi R}{v}$

Also, $I = \dfrac{q}{T} = \dfrac{qv}{2\pi R}$

$\therefore \quad \mu = \left(\dfrac{qv}{2\pi R}\right)(\pi R^2) = \dfrac{qvR}{2}.$

35. (d) : Energy of n^{th} orbit of hydrogen atom is given by

$$E_n = \frac{-13.6}{n^2} \text{ eV}$$

For ground state, $n = 1$

$$\therefore \quad E_1 = \frac{-13.6}{1^2} = -13.6 \text{ eV}$$

For first excited state, $n = 2$

$\therefore \quad E_2 = \frac{-13.6}{2^2} = -3.4$ eV

Kinetic energy of an electron in the first excited state is
$K = -E_2 = 3.4$ eV.

36. (d) : For a light source of power P watt, the intensity at a distance d is given by

$$I = \frac{P}{4\pi d^2}$$

where we assume light to spread out uniformly in all directions *i.e.* it is a spherical source.

$\therefore \quad I \propto \frac{1}{d^2}$ or $\frac{I_1}{I_2} = \frac{d_2^2}{d_1^2}$

or, $\frac{I_1}{I_2} = \left(\frac{1}{0.5}\right)^2$ or, $\frac{I_1}{I_2} = 4$ or, $I_2 = \frac{I_1}{4}$.

In a photoelectric emission, the number of photoelectrons liberated per second from a photosensitive metallic surface is proportional to the intensity of the light. When a intensity of source is reduced by a factor of four, the number of photoelectrons is also reduced by a factor of 4.

37. (b) : $x(t) = a\sin\omega t$ (from the equilibrium position)
At $x(t) = a/2$

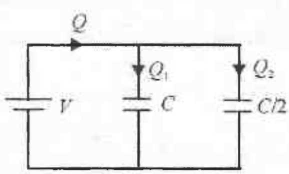
$\therefore \quad \frac{a}{2} = a\sin(\omega t)$

$\sin\left(\frac{\pi}{6}\right) = \sin(\omega t)$ or, $\frac{\pi}{6} = \frac{2\pi t}{T}$ $\left[\because \omega = \frac{2\pi}{T}\right]$

or, $t = T/12$.

38. (c) : In a cubic crystal structure
$a = b = c$, $\alpha = \beta = \gamma = 90°$.

39. (b) : As the capacitors are connected in parallel, therefore potential difference across both the condensors remains the same.



$\therefore \quad Q_1 = CV$; $Q_2 = \frac{C}{2}V$

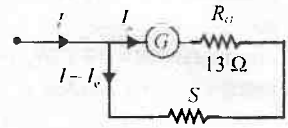
Also, $Q = Q_1 + Q_2 = CV + \frac{C}{2}V = \frac{3}{2}CV$.

Work done in charging fully both the condensors is given by

$$W = \frac{1}{2}QV = \frac{1}{2}\times\left(\frac{3}{2}CV\right)V = \frac{3}{4}CV^2.$$

40. (a) : According to Stefan's law,
rate of energy radiated $E \propto T^4$
where T is the absolute temperature of a black body.
$\therefore \quad E \propto (727 + 273)^4$ or $E \propto [1000]^4$.

41. (a) : Let the shunt resistance be S.



Given: $I = 750$ A,
$I_g = 100$ A, $R_G = 13\ \Omega$
From the figure,

$I_g R_G = (I - I_g)S$

or $100 \times 13 = [750 - 100]S$ or $1300 = 650\,S$

$\therefore \quad S = 1300/650 = 2\ \Omega$.

42. (c) : Efficiency of an engine, $\eta = 1 - \frac{T_2}{T_1}$

where T_1 is the temperature of the source and T_2 is the temperature of the sink.

$\therefore \quad \frac{1}{6} = 1 - \frac{T_2}{T_1}$ or, $\frac{T_2}{T_1} = \frac{5}{6}$ ... (i)

When the temperature of the sink is decreased by 62°C (or 62 K), efficiency becomes double.
Since, the temperature of the source remain unchanged

$\therefore \quad 2\times\frac{1}{6} = 1 - \frac{(T_2 - 62)}{T_1}$ or, $\frac{1}{3} = 1 - \frac{(T_2 - 62)}{T_1}$

or, $\frac{2}{3} = \frac{T_2 - 62}{T_1}$ or, $2T_1 = 3T_2 - 186$

or, $2T_1 = 3\left[\frac{5}{6}\right]T_1 - 186$ [using (i)]

$\therefore \quad \left[\frac{5}{2} - 2\right]T_1 = 186$ or, $\frac{T_1}{2} = 186$

or, $T_1 = 372$ K $= 99°$C.

43. (c) : In electromagnetic wave, electric and magnetic field are in phase and perpendicular to each other and also perpendicular to the direction of the propagation of the wave.

44. (d) : In series LCR, current is maximum at resonance.

$\therefore$ Resonant frequency $\omega = \frac{1}{\sqrt{LC}}$

$\therefore \quad \omega^2 = \frac{1}{LC}$ or, $L = \frac{1}{\omega^2 C}$

Given $\omega = 1000\ s^{-1}$ and $C = 10\ \mu$F

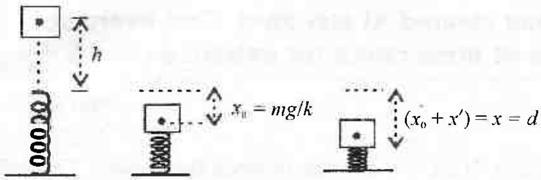
$\therefore \quad L = \frac{1}{1000\times1000\times10\times10^{-6}} = 0.1$ H $= 100$ mH.

45. (d) : Above Curie temperature, ferromagnetic material become paramagnetic.

46. When a mass falls on a spring from a height h the

work done by the loss of potential energy of the mass is stored as the potential energy of the spring.

One can write $mg(h+d)=\frac{1}{2}kd^2$



$$mg(h+d)=\frac{1}{2}kx^2=\frac{1}{2}kd^2$$

The two energies are equal.
If work done is initial P.E. – final P.E., it is zero.
Work done is totally converted (assuming there is no loss). The work done in compression or expansion is always positive as it is $\propto x^2$. The answer expected is

$$mg(h+d)-\frac{1}{2}kd^2 \quad \text{or,} \quad \frac{1}{2}kd^2-mg(h+d)$$

as seen from options, but it is not justified.
Question could have been more specific like work done by oscillation.

47. (b) : In a uniform magnetic field, a charged particle is moving in a circle of radius R with constant speed v.

$$\therefore \quad \frac{mv^2}{R}=Bqv \quad \text{or,} \quad R=\frac{mv}{Bq} \qquad \text{... (i)}$$

Time period, $T=\frac{2\pi R}{v}=\frac{2\pi mv}{Bqv}=\frac{2\pi m}{Bq}$ ... (ii)

Time period T does not depend on both R and v because when v is changed, R is also changed proportionately and for period, it is R/v that is taken.

48. (d) : $T_i - T_n = T_n - T_c$
$T_i = 2T_n - T_c$ or, $T_i = 2T_n - 0°C$
or $T_n = T_i/2$.

49. (c) : Power P radiated by the sun with its surface temperature $(t + 273)$ is given by Stefan's Boltzmann law.

$$P = \sigma e\, 4\pi r^2(t + 273)^4$$

where r is the radius of the sun and the sun is treated as a black body where $e = 1$.
The radiant power per unit area received by the surface at a distance R from the centre of the sun is given by

$$S=\frac{P}{4\pi R^2}=\frac{\sigma 4\pi r^2(t+273)^4}{4\pi R^2}=\frac{r^2\sigma(t+273)^4}{R^2}.$$

50. (d) : p-type semiconductor.

Analysis of CBSE-PMT (Prelims) 2007

Topics	Ques. Asked
1. Units and Dimensions	1
2. Motion in One Dimension	3
3. Motion in Two Dimensions	2
4. Laws of Motion & Friction	1
5. Work, Power and Energy	1
6. CM & Rotational Motion	3
7. Gravitation	1
8. Oscillation	4
9. Waves	0
10. Heat and Thermodynamics	3
11. Electrostatics	4
12. Current Electricity	1
13. Thermal & Chemical Effect of Current	3
14. Magnetic Effect of Current	2
15. Magnetism	2
16. Electromagnetic Induction & Alternating Current	3
17. Electromagnetic Waves	1
18. Optics	2
19. Modern Physics	9
20. Solids & Semiconductor Devices	4

Thought Provoking Problems in S.H.M. & WAVE MOTION

By : Prof. R.S. Randhawa

1. Two waves of equal amplitude, both travelling along the +ve x direction and wavelengths $\lambda_1 = \lambda$, $\lambda_2 - \lambda + \Delta\lambda$ superpose on a string. Discuss the shape of the combination at $t = 0$, compare it with the beats phenomena. Determine the distance from peak to peak of the amplitude modulating factor and number of wavelengths contained between successive zeros of the modulating envelope.

2. If l_1 is the length of an imperfectly adjusted pendulum which gains n seconds in one hour at the same place, find the length of the second pendulum.

3. Find the natural frequency of the semicircular shell of mass m and radius r which rolls without slipping.

4. The speaker of public address system emits 20 W power. Considering it a point source (a) What is the sound intensity level at a point 4 m away? (b) At what distance from the speaker does the sound intensity level drop to half the level that it has at 4 m?

5. Suppose the sound intensity level in Chandigarh has been increasing by about 1dB annually. What percentage increase in intensity does this correspond to? In about how many years would the intensity of sound double if it increased at 1dB annually?

SOLUTION

1. The two superposing waves are

$$y_1 = A\sin\left[\frac{2\pi}{\lambda_1}(x - vt)\right], \quad y_2 = A\sin\left[\frac{2\pi}{\lambda_2}(x - vt)\right]$$

Since wave number $k = 1/\lambda$;
From principle of superposition,
$\therefore\ y = y_1 + y_2 = A\ \{\sin\ [2\pi k_1(x - vt) + \sin\ [2\pi k_2\ (x - vt)]\}$

If $t = 0$, then
$y = A\ [\sin 2\pi k_1 x + \sin 2\pi k_2 x]$
$= 2A\cos\ [\pi\ (k_1 - k_2)x]\ \sin\ [\pi\ (k_1 + k_2)x]$

The amplitude modulating factor is
$A_M = 2A\cos\ [\pi\ (k_1 - k_2)x]$.

The distance between points where amplitude modulating factor becomes zero is defined by the change of x corresponding to an increase of π in the quantity $\pi(k_1 - k_2)x$. Let us denote this distance by D, we have

$$\pi(k_1 - k_2)D = \pi \text{ or } D = \frac{1}{k_1 - k_2} = \frac{\lambda_1\lambda_2}{\lambda_2 - \lambda_1} \text{ or } D \approx \frac{\lambda^2}{\Delta\lambda}.$$

Number of wavelengths contained in this distance is $\frac{D}{\lambda} \sim \frac{\lambda}{\Delta\lambda}$.

2. For second pendulum, $1 = \pi\sqrt{\frac{l}{g}}$ ...(i)

For the pendulum that gains n second,

$$\frac{3600}{3600+n} = \pi\sqrt{\frac{l_1}{g}} \qquad \text{...(ii)}$$

For the pendulum that looses n sec;

$$\frac{3600}{3600-n} = \pi\sqrt{\frac{l_2}{g}} \qquad \text{...(iii)}$$

Dividing equation (i) by (ii), we get

$$\frac{3600+n}{3600} = \sqrt{\frac{l}{l_1}} \qquad \text{...(iv)}$$

Dividing (i) by equation (iii), we get

$$\frac{3600-n}{3600} = \sqrt{\frac{l}{l_2}} \qquad \text{...(v)}$$

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Adding equation (iv) and equation (v)

$$2=\sqrt{\frac{I}{I_1}}+\sqrt{\frac{I}{I_2}} \qquad ...(vi)$$

On squaring both sides and solving,

$$I=\frac{4I_1I_2}{I_1+I_2+2\sqrt{I_1I_2}}.$$

3. $(KE)_{max}=\frac{1}{2}I_A\,\omega^2 = mr\,(r-a)\,\omega^2$

where, $I_A = I_{CM} + m\,(r-a)^2$

$= I_0 - ma^2 + m\,(r-a)^2$

$= 2mr\,(r-a)$

$(KE)_{max} = (PE)_{max}$

$mr(r-a)\,\omega^2 = mga\,(1-\cos\theta)$

4.(a) Intensity at a radial distance of 4 m from the source.

$$I=\frac{P_{av}}{4\pi r^2}=\frac{20}{4\pi(4)^2}=9.9\times10^{-2}\ \text{W/m}^2$$

$\therefore$ Sound intensity level,

$$\beta = 10\log_{10}\left(\frac{I}{I_0}\right)$$

$$\beta=10\log_{10}\left(\frac{9.9\times10^{-2}}{10^{-12}}\right)=110\ \text{dB}.$$

(b) Half the intensity level $\beta'=\frac{\beta}{2}=55\ \text{dB}$

$$\beta'=10\log_{10}\left(\frac{I'}{I_0}\right)\ \text{dB}.$$

$$\log_{10}\left(\frac{I'}{I_0}\right)=\frac{\beta'}{10\ \text{dB}} \Rightarrow I'=I_0\times10^{\beta'/10\ \text{dB}}$$

$$r'=\sqrt{\frac{P_{av}}{4\pi I_0(10^{\beta'/10\text{dB}})}}$$

If we assume no dissipation of energy occurs the total power radiated remains constant at 20 W m^{-2} and

$$r'=\sqrt{\frac{20}{4\pi\times(1\times10^{-12})(10^{55/10})}}=2.2\ \text{km}$$

5. As intensity level β is given by

$$\beta=10\log\frac{I}{I_0}\ \therefore\ I=I_0e^{\frac{\ln10}{10}\beta}$$

On differentiation we get $\frac{dI}{d\beta}=\frac{\ln10}{10}I$

$$\text{Hence } \frac{\Delta I}{I}\approx\frac{\frac{dI}{d\beta}\Delta\beta}{I}=\frac{\ln10}{10}\Delta\beta$$

for $\Delta\beta\approx1$ dB, we get $\frac{\Delta I}{I}=23\%$

On integrating $\frac{dI}{I}=\frac{\ln10}{10}\frac{d\beta}{dt}dt,$

$$\text{we get } \ln\frac{I(t_2)}{I(t_1)}=\frac{\ln10}{10}\int_{t_1}^{t_2}\frac{d\beta}{dt}\,dt$$

As $\frac{d\beta}{dt}=1$ dB/ year and taking $I(t_2)=2I(t_1)$, we have

$$\Delta t\approx t_2-t_1\sim\frac{10\ln2}{\ln10}=3\ \text{year}.$$

which is the required time for intensity to double. ■

PRACTICE PAPER FOR IIT-JEE 2007

According to New Pattern

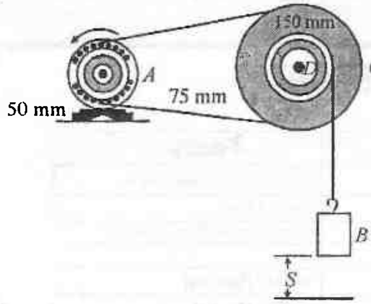
Exam on 8th April

PAPER - I

PHYSICS

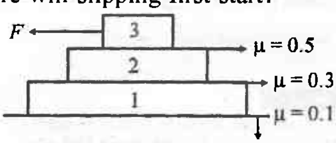
Section - I (Q. No. 1 to 12)
(Only one option is correct)

1. Starting from rest when $S = 0$, pulley A is given a constant angular acceleration of 6 rad/s^2. The speed of block B when it has risen by $S = 30$ m will be (Given: radius of pulley $r_A = 50$ mm, $r_C = 150$ mm, $r_D = 75$ mm).



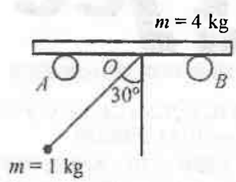
(a) 2 m/s (b) 3 m/s
(c) 4 m/s (d) none of these

2. If force F is increasing with time and at $t = 0$, $F = 0$, where will slipping first start?



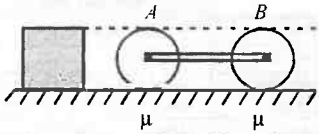
(a) between 3 kg and 2 kg
(b) between 2 kg and 1 kg
(c) between 1 kg and ground
(d) both (a) and (b)

3. A ball of mass 1 kg is suspended by an inextensible string 1m long attached to a point O of a smooth horizontal bar resting on a fixed smooth supports A and B. The ball is released from rest from the position when the string makes an angle of 30^0 with the vertical. The mass of the bar is 4 kg. The displacement in meters of the bar when the string makes the maximum angle on the other side of the vertical is



(a) 0 (b) 0.2
(c) 0.25 (d) 0.5

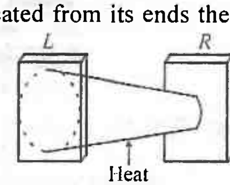
4. Two identical discs of radius R and mass m each are connected by a light rod as shown in figure. A block of height $2R$ and mass $2m$ collides elastically with the disc A. Just after the collision, the direction of frictional forces on A and B respectively will be



(a) leftwards, leftwards (b) leftwards, rightwards
(c) rightwards, leftwards (d) rightwards, rightwards

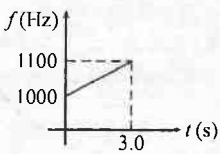
5. Suppose that earth suddenly shrinks in size under some internal forces. Assume that it remains perfectly spherical and its mass remains unchanged. Then,
(a) the duration of day will decrease
(b) the kinetic energy of rotation about its own axis will remain unchanged
(c) the duration of year will decrease
(d) all the above

6. A conical metallic body is heated at middle. If the body was truncated from its ends then



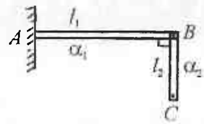
(a) there will be no effect on the body
(b) no strain is produced in the body
(c) maximum compressive stress will be on the side of the body towards L
(d) maximum compressive stress will be on the side of body towards R

7. A detector is released from rest over a source of sound of frequency $f_0 = 10^3$ Hz. The frequency observed by the detector at time t is plotted in the graph. The speed of sound in air is (g = 10 m/s²)



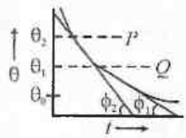
(a) 330 m/s (b) 350 m/s
(c) 300 m/s (d) 310 m/s

8. Two thin rods are arranged as shown in figure. The system is heated uniformly and slowly such that it's temperature increases at a rate $R = \frac{dT}{dt}$. The speed of point C will be



(a) zero (b) $(l_1\alpha_1 + l_2\alpha_2)R$
(c) $(l_1^2\alpha_1^2 + l_2^2\alpha_2^2)^{1/2}R$ (d) none of these

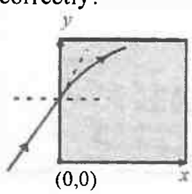
9. A body cools in a surrounding which is at a constant temperature of θ_0. Assume that it obeys Newton's law of cooling. Its temperature θ is plotted against time t. Tangents are drawn to the curve at the points $P(\theta = \theta_2)$ and $Q(\theta = \theta_1)$. These tangents meet the time axis at angles of ϕ_2 and ϕ_1 as shown in figure. Then



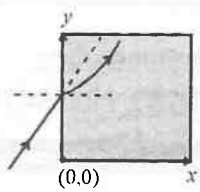
(a) $\frac{\tan\phi_2}{\tan\phi_1} = \frac{\theta_1 - \theta_2}{\theta_2 - \theta_0}$ (b) $\frac{\tan\phi_2}{\tan\phi_1} = \frac{\theta_2 - \theta_0}{\theta_1 - \theta_0}$
(c) $\frac{\tan\phi_1}{\tan\phi_2} = \frac{\theta_1}{\theta_2}$ (d) $\frac{\tan\phi_1}{\tan\phi_2} = \frac{\theta_2}{\theta_1}$

10. A light ray is incident on a glass slab with variable refractive index given by $\mu = 1.5\,(1 + x)$ where x, y axes are taken as usual. Outside refractive index is 2. Which of the following figures represents the trajectory of the ray correctly?

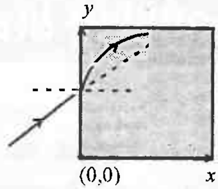
(a)



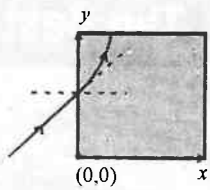
(b)



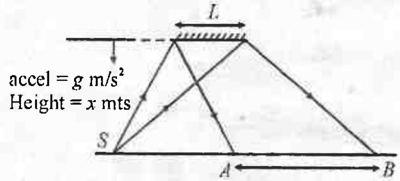
(c)



(d)

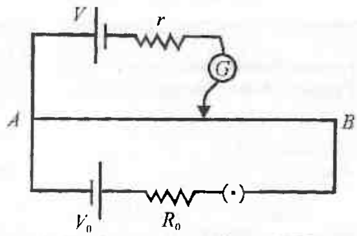


11. A plane mirror falling vertically as shown in the figure. If S is a point source of light, the rate of increase of the length AB is



(a) directly proportional to x
(b) constant but not zero
(c) inversely proportional to x
(d) zero

12. In the given potentiometer arrangement, the null point

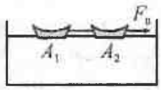


(a) can be obtained for any value of V
(b) null point can be obtained only if $V < V_0$
(c) null point can be obtained only if $V > V_0$
(d) can never be obtained

Section - II (Q. No. 13 to 20)
(More than one option may be correct)

13. A particle strikes a horizontal smooth floor with a velocity u making an angle θ with the floor and rebounds with velocity v making an angle ϕ with the floor. The coefficient of restitution between the particle and the floor is e. Then
(a) the impulse delivered by the floor to the body is $mu(1 + e)\sin\theta$
(b) $\tan\phi = e\tan\theta$
(c) $v = u\sqrt{1-(1-e^2)\sin^2\theta}$
(d) the ratio of the final kinetic energy to the initial kinetic energy is $\cos^2\theta + e^2\sin^2\theta$

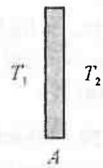
14. Two boats of base areas A_1 and A_2, connected by a string are being pulled by an external force F_0. The viscosity of water is η and depth of the water body is H. When the system attains a constant speed, the tension in the thread will be



(a) zero (b) $F_0 \dfrac{A_1}{(A_1 + A_2)}$

(c) $F_0 \dfrac{A_2}{(A_1 + A_2)}$ (d) none of these

15. A large flat plate of area A is kept such that the temperature of surroundings to it's left is T_1 and to it's right is T_2. Assume that heat transfer takes place only through radiation and that the plate has a very large thermal conductivity. The equilibrium temperature of the plate will be



(a) $\left(\dfrac{T_1^4 + T_2^4}{2}\right)^{1/4}$ (b) $(T_1^4 + T_2^4)^{1/4}$

(c) somewhere between T_1 and T_2 but the exact value cannot be predicted by given data

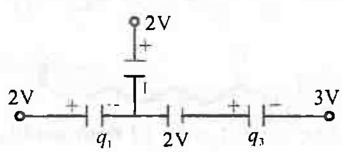
(d) none of these

16. A radioactive material of half-life T was produced in a nuclear reactor at two different instants. The quantity produced second time was twice of that produced first time. If now their present activities are A_1 and A_2 respectively then their age difference equals

(a) $\dfrac{T}{\ln 2} \ln \dfrac{2A_1}{A_2}$ (b) $T \ln \dfrac{A_1}{A_2}$

(c) $\dfrac{T}{\ln 2} \ln \dfrac{A_2}{2A_1}$ (d) $T \ln \dfrac{A_2}{2A_1}$

17. A part of the circuit is shown in the figure. All the capacitors have capacitance of 2μF. Choose the correct alternative



(a) charge on capacitor C_1 is zero

(b) charge on capacitor C_2 is zero

(c) charge on capacitor C_3 is zero

(d) charge on none of the capacitors is zero

18. A planet having surface temperature T K has a solar constant S. A solid angle θ is subtended by the sun at the planet

(a) $S \propto T^2$ (b) $S \propto T^4$ (c) $S \propto \theta$ (d) $S \propto \theta^2$

19. Starting from rest a particle is first accelerated for time t_1 with constant acceleration a_1 and then stops in time t_2 with constant retardation a_2. Let v_1 be the average velocity in this case and s_1 the total displacement. In the second case it is accelerated for the same time t_1 with constant acceleration $2a_1$ and comes to rest with constant retardation a_2 in time t_3. If v_2 is the average velocity in this case and s_2 the total displacement, then

(a) $v_2 = 2v_1$ (b) $2v_1 < v_2 < 4v_1$

(c) $s_2 = 2s_1$ (d) $2s_1 < s_2 < 4s_1$

20. A particle is projected from a point P with a velocity v at an angle θ with horizontal. At a certain point Q it moves at right angle to its initial direction. Then

(a) velocity of particle at Q is $v\sin\theta$

(b) velocity of particle at Q is $v\cot\theta$

(c) time of flight from P to Q is (v/g) cosecθ

(d) time of flight from P to Q is (v/g)secθ

CHEMISTRY

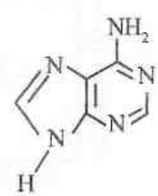
Section - 1 (Q. No. 21 to 32)
(Only one option is correct)

21. Which of the following will have structure different from others ?

(a) I_2O_5 (b) $S_2O_5^{2-}$ (c) Cl_2O_5 (d) N_2O_5

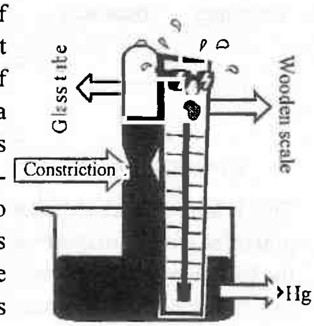
22. Denticity of ligands 1,4-diaza-2,5-cyclohexadiene, [fig (a)], and adenine, [fig (b)] is

(a) 

(b) 

(a) 1, 2 (b) 2, 2 (c) 1, 1 (d) 2, 5

23. A manufacturer of barometers discovered that a recently prepared lot of hundred barometers had a notable defect : the glass tube in these cases had non-uniform cross section due to a slight constriction towards the center. How can the manufacturer correct this



defect?

(a) This causes no defect in the reading
(b) By introducing some air in the empty space over Hg column in the tube
(c) By adjusting the marking on the wooden scale such that the readings in the zone of constriction should indicate the distance on curved surface of glass measured in vertical direction
(d) He should throw these barometers and make fresh ones if he wants to save his reputation

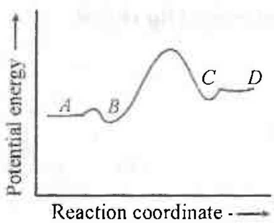
24. A mercury drop of radius 1 cm is sprayed into 10^6 droplets of equal size. Calculate the work done if surface tension of mercury is 35×10^{-3} N/m.

(a) 6.36×10^{-5} J (b) 4.356×10^{-3} J
(c) 3.333×10^{-3} J (d) 5.64×10^{-6} J

25. When aqueous ammonia is added to silver chloride, the salt dissolves. Which of the following helps to explain the observation?

(a) Ammonia depresses the concentration of $[Cl^-]$
(b) NH_4^+ and Cl^- have great affinity for each other
(c) The ionic product of $[Ag^+]_{aq.}$ and $[Cl^-]_{aq.}$ in the solution is less than or equal to the solubility product of silver chloride just after adding ammonia
(d) Ag precipitates as complex ion $[Ag(NH_3)_2]Cl$.

26. A simple model for enzyme-catalyzed reaction is given by the following set of equations



$$\underset{\text{(enzyme)}}{E} + \underset{\text{(reactant)}}{S} \xrightleftharpoons{\text{Fast}} \underset{\text{(intermediate 1)}}{ES}$$

$$\underset{\text{(intermediate 1)}}{ES} \rightleftharpoons \underset{\text{(intermediate 2)}}{EP}$$

$$\underset{\text{(intermediate 2)}}{EP} \rightleftharpoons \underset{\text{(enzyme)}}{E} + \underset{\text{(product)}}{P}$$

This is known as the Michaelis-Menten mechanism. The potential energy diagram is shown in figure. Which of the following sets of identifications is correct? (Assume that temperature and pressure are constant.)

	A	*B*	*C*	*D*
(a)	*E+P*	*EP*	*ES*	*E+S*
(b)	*ES*	Activated complex	*EP*	Activated complex
(c)	*EP*	Activated complex	*ES*	Activated complex
(d)	*E+S*	*ES*	*EP*	*E+P*

27. Which of the following will be a β-emitter ?

(a) ${}^{7}_{5}B$ (b) ${}^{2}_{1}D$
(c) ${}^{22}_{10}Ne$ (d) all of these.

28. Which of the following has minimum oxidation potential?

(a) Li (b) Na (c) Rb (d) Cs.

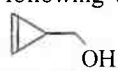
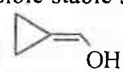
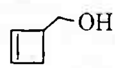
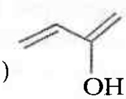
29. Which of the following will undergo minimum hydrolysis with water?

(a) $AsCl_3$ (b) $SnCl_2$ (c) $SnCl_4$ (d) $CdCl_2$

30. Which of the following gases when bubbled through lime water will not turn it milky and then colourless?

(a) SO_3 (b) CO_2 (c) SO_2 (d) $COCl_2$

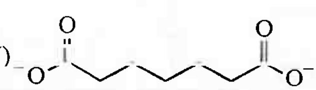
31. If C_4H_5OH represents a primary alcohol, which of the following will be the possible stable structure?

(a) 
(b) 
(c) 
(d) 

32. Consider

(I)  (II) 

(III) 

(IV) 

The correct order of their acidity is

(a) (II) > (I) > (III) > (IV)
(b) (II) > (III) > (I) > (IV)
(c) (IV) > (III) > (II) > (I)
(d) none of these

Section - II (Q. No. 33 to 40)

(More than one option may be correct)

33. When an aqueous solution of lithium chloride is electrolysed using graphite electrodes

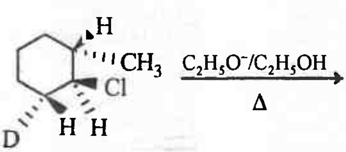
(a) pH of the resulting solution increases
(b) pH of the resulting solution decreases
(c) as the current flows, pH of the solution around the cathode increases
(d) as the current flows, pH of the solution around the anode increases

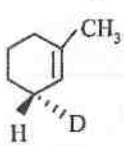
34. Which of the following is unstable(does not exist at room temperature)?
(a) CuI_2 (b) $CuCl_2$ (c) TlF_3 (d) $SnPbO_3$

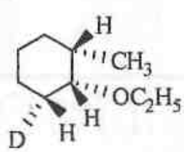
35. Which of the following mixtures, when dissolved in water, will give hydrogen gas at cathode when electrolysed using inert electrodes under standard conditions?
(a) K_2CO_3 and Na_2SO_4 (b) NaCl and $CaCl_2$
(c) $Ba(NO_3)_2$ and $Pb(NO_3)_2$
(d) $CuCl_2$ and potash alum

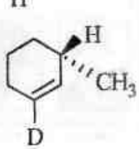
36. Electrolysis of aqueous solutions of which of the following substances results in only decomposition of water?
(a) Potassium chloride (b) Zinc sulphate
(c) Potassium hydroxide (d) Sodium phosphate

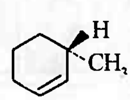
37. The probable products of the following reaction can be



(a) 

(b) 

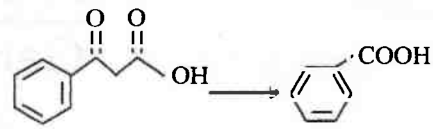
(c) 

(d) 

38. Which of the following is correct?
(a) CsI_3 is thermally more stable than $[N(CH_3)_4]^+I_3^-$
(b) $BaSO_4$ and $KMnO_4$ are isomorphous
(c) $CsClO_4$ is less soluble than $LiClO_4$ (in water)
(d) None of these.

39. $K_2S_2O_8$, acidic $K_2S_2O_8$ and acidic MnO_2 oxidise I^-, Br^-, Cl^- to I_2, Br_2 and Cl_2, respectively from the given data, the sequence that represents the correct order of increasing oxidisng ability is
(a) acidic $MnO_2 > K_2S_2O_8 > Cl_2$
(b) $I_2 > K_2S_2O_8 > Br_2$ (c) $K_2S_2O_8 > I_2 > Br_2$
(d) $Cl_2 > K_2S_2O_8 > Br_2$.

40. The following conversion reaction can be carried out by using reaction sequence/s.



(a) $\xrightarrow{NaBH_4} \xrightarrow{Al_2O_3,\ \Delta} \xrightarrow{O_3/H_2O(\text{oxidative})}$
(b) $\xrightarrow{Zn/Hg/HCl,\ \Delta} \xrightarrow{Br_2/h\nu} \xrightarrow{KCN} \xrightarrow{H_3O^+,\ \Delta}$
(c) $\xrightarrow{\text{Heat}} \xrightarrow{I_2/NaOH,\ \Delta} \xrightarrow{H^+}$
(d) $KMnO_4/OH^-$ / heat

MATHEMATICS

Section - I (Q. No. 41 to 52)
(Only one option is correct)

41. If $f(x) = \int_0^x \frac{dt}{(f(t))^2}$ and $\int_0^{2/3} \frac{dt}{(f(t))^2} = \sqrt[3]{2}$, $f(72)$ is equal to
(a) 2 (b) 3 (c) 6 (d) 0

42. If the slope of tangent to the curve $y = f(x)$ is $\dfrac{\frac{1}{2}.\sin^2 x}{f(x)}$ then $f(x)$ is periodic function with principal period
(a) π (b) 2π
(c) $\frac{\pi}{2}$ (d) non periodic

43. $\int_{\sin\theta}^{\cos\theta} f(x\tan\theta)\, dx \left(\theta \neq \frac{n\pi}{2}, n \in I\right)$ is equal to
(a) $-\cos\theta \int_1^{\tan\theta} f(x\sin\theta)\, dx$
(b) $-\tan\theta \int_{\cos\theta}^{\sin\theta} f(x)\, dx$ (c) $\sin\theta \int_1^{\tan\theta} f(x\cos\theta)\, dx$
(d) $\frac{1}{\tan\theta} \int_{\sin\theta}^{\sin\theta\tan\theta} f(x)\, dx$

44. The value of $\lim_{n\to\infty} \left(\frac{n!}{n^n}\right)^{\frac{2n^4+1}{5n^5+1}}$ is equal to

(a) 1 (b) 0 (c) $\left(\frac{1}{e}\right)^{2/5}$ (d) $e^{2/5}$

45. If $\bar{p}$ and $\bar{q}$ are two mutually perpendicular unit vectors and if the vectors

$\{r\bar{\alpha}+r\bar{\beta}+s(\bar{\alpha}\times\bar{\beta})\}$

$\{\bar{\alpha}+(\bar{\alpha}\times\bar{\beta})\}$ and $\{s\bar{\alpha}+s\bar{\beta}+t(\bar{\alpha}\times\bar{\beta})\}$

are coplanar, then s

(a) is the A.M. of r and t
(b) is the G.M. of r and t
(c) is the H.M. of r and t
(d) none of these

46. The auxiliary circle of a family of ellipse passes through origin and makes intercept of 8 and 6 units on the x-axis and the y-axis respectively. If eccentricity of all such family of ellipse is $\frac{1}{2}$ then locus of the focus will be

(a) $\frac{x^2}{16}+\frac{y^2}{9}=25$
(b) $4x^2+4y^2-32x-24y+75=0$
(c) $\frac{x^2}{16}-\frac{y^2}{9}=25$ (d) none of these

47. Locus of point of intersection of the perpendicular lines are one belonging to

$(x+y-2)+\lambda(2x+3y-5)=0$ and other to

$(2x+y-11)+\lambda(x+2y-13)=0$ is a

(a) circle (b) straight line
(c) pair of lines (d) none of these

48. The length of the latus rectum of the hyperbola $\frac{x^2}{a^2}-\frac{y^2}{b^2}=1$ for which there is only one tangent at a distance of 1 unit from the focus (6, 0) is

(a) $\frac{22}{5}$ (b) $\frac{11}{5}$
(c) $\frac{5}{11}$ (d) none of these.

49. If coefficient x^n in $(1+x)^{101}(1-x+x^2)^{100}$ is non-zero, then n cannot be of the form

(a) $3t+1$ (b) $3t$ (c) $3t+2$ (d) $4t+1$

50. Five teams of equal strength play against each other in a tournament and each match either ends in a win or loss for a team. The probability that no teams win all its games or loss all its games is

(a) $\frac{17}{32}$ (b) $\frac{5}{16}$
(c) $\frac{15}{32}$ (d) none of these

51. If $\left(\frac{3-z_1}{2-z_1}\right)\left(\frac{2-z_2}{3-z_2}\right)=k$,

then points $A(z_1)$, $B(z_2)$ $C(3, 0)$ and $D(2,0)$ (taken in clockwise sense) will

(a) lie on a circle only for $k>0$
(b) lie on a circle only for $k<0$
(c) lie on a circle $\forall\, k\in R$
(d) be vertices of a square $\forall\, k\in(0,1)$

52. Each square of a 3×3 board is coloured either red or blue at random (each having probability 1/2). The probability that there is no 2×2 red square is

(a) $\frac{417}{512}$ (b) $\frac{117}{512}$
(c) $\frac{201}{512}$ (d) none of these

Section II (Q. No. 53 to 60)
(More than one option may be correct)

53. Let e be the eccentricity of a hyperbola and $f(e)$ be the eccentricity of its conjugate hyperbola then

$\int_1^3 \underbrace{f\,f\,f\ldots f(e)}_{n\text{ times}}\,de$ is equal to

(a) 4 if n is even (b) 4 if n is odd
(c) 2 if n is even (d) $2\sqrt{2}$ if n is odd

54. Which of the following functions are odd functions?

(a) $f(x)=\frac{x}{e^{|x|}+\cos x}$
(b) $f(x)=x^2\ln\left(\sqrt{x^6+1}+x^3\right)$
(c) $f(x)=\left(\frac{2^x-1}{2^x+1}\right)[g(x)+g(-x)]$
(d) $f(x)=\{g(x)+g(-x)\}\{h(x)+h(-x)\}$

55. For the function $f(x)=\cos^{-1}x+\cos^{-1}x^2$ which of the following statements is / are true?

(a) $f(x)$ is always decreasing
(b) $f(x)$ is decreasing in [0, 1] and increasing in [–1,0]
(c) $f(x)$ has only one local maxima
(d) $f(x)$ has only one local minima

56. If $f(x)=\begin{cases}3x^2+2|x-1|-1 & 0<x<1\\ 1+x & 1<x<3\end{cases}$, then

(a) $f(x)$ is increasing in [0,1]
(b) $f(x)$ is continuous in [0,3]
(c) $f'(x)$ does not exist at $x = 1$
(d) $f(x)$ has a maximum at $x = 1$

57. If L_1 and L_2 are two lines belonging to family of lines

$(3+2\lambda)x+(4+3\lambda)y-7-5\lambda=0$ (λ is parameter)

such that at maximum and minimum distance from (2,3) respectively, then the equation of lines passing through (1,2) and making equal with L_1 and L_2 is/are

(a) $x + 2y = 7$ (b) $3x + y = 5$
(c) $x - 3y = -5$ (d) none of these

58. Let $\hat{\alpha},\hat{\beta}$ and $\hat{\gamma}$ be the unit vectors such that $\hat{\alpha}$ and $\hat{\beta}$ are mutually perpendicular and $\hat{\gamma}$ is equally inclined to $\hat{\alpha}$ and $\hat{\beta}$ at an angle θ. If $\hat{\gamma}=x\hat{\alpha}+y\hat{\beta}+z(\hat{\alpha}+\hat{\beta})$, then

(a) $z^2 = 1 - 2x^2$ (b) $z^2 = 1 - 2y^2$
(c) $z^2 = 1 - x^2 - y^2$ (d) $x^2 = y^2$

59. If $p + q + r = 0 = a + b + c$, then the value of the determinant $\begin{vmatrix}pa & qb & rc\\ qc & ra & pb\\ rb & pc & qa\end{vmatrix}$ is

(a) $abc\begin{vmatrix}p & q & r\\ q & p & p\\ r & r & q\end{vmatrix}$ (b) $pqr\begin{vmatrix}a & b & c\\ c & a & b\\ b & c & a\end{vmatrix}$

(c) $(a^3 + b^3 + c^3)(p^3 + q^3 + r^3)$
(d) 0.

60. If a, b, c form A.P. with common difference $d(\neq 0)$ and x, y, z form a G.P. with common ratio $r(\neq 1)$, then the area of the triangle with vertices; (a, x), (b, y) and (c, z) is independent of

(a) a (b) b (c) x (d) r

PAPER - II

PHYSICS

Section I (Q.No. 1 to 10)

Comprehensive questions

Comprehension -1 : *A stable collection of charges*

One important question regarding a static distribution of charges was asked long back in 1904 by J.J Thomson, the discoverer of electron. Thomson's question was this: How should n identical point charges be distributed on a plane circular area such that the total electrostatic energy of the distribution is minimum?

Since the time of Thomson, a lot of effort has gone into answering this seemingly simple question. Common sense would suggest that N identical charges, constrained to be on a circular area, would lie on the circumference and arrange themselves on a regular polygon of N sides. But the answer is not that simple.

In 1985 Satanand Gupta came up with a very surprising answer for the distribution of these charges. He showed that the simple intuitive answer is all right as long as there are 11 or less charges. When there are 12 charges, be found that for minimum energy, 11 charges should be spaced symmetrically on the circumference of the circle and one charge should sit at the centre. He said that for all $N > 12$, the minimum energy arrangement will have $N - 1$ charges equally spaced on the circumference and one charge at the centre of the circle.

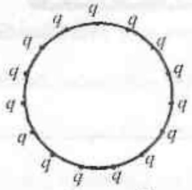
Improved calculations in 1986 by Tikam Roopchandani indicated that Satanand's results are valid only for N = 12 to 17. For $N = 18$, he found that 16 charges should be placed symmetrically on the circumference and the two charges should be placed symmetrically about the centre at some distance from it. When one more charge is added to this (*i.e.* $N = 19$), the added charge should go to the centre and rest everything remains same. For greater values of N no conclusive results have yet been obtained and this problem is still keeping many scientists occupied. May be in future one of you would be able to get to the correct result for a general value of N!

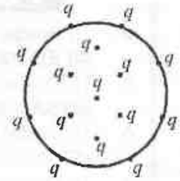
1. Suppose that you are given six identical point charges and you have arranged them in a circular region of area A such that the potential energy of the system is minimum. Then the distance between the two adjacent charges would be

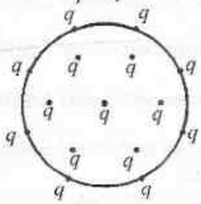
(a) $\sqrt{\frac{A}{2\pi}}$ (b) $\sqrt{\frac{A}{\pi}}$ (c) $\frac{1}{2}\sqrt{\frac{A}{\pi}}$ (d) $\sqrt{A}$

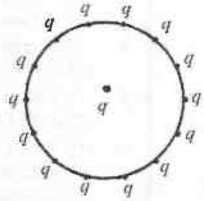
2. If 15 charges are to be arranged on a circular region

such that the potential energy of the system is minimum then they should be arranged as

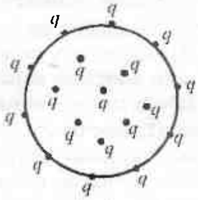
(a) 

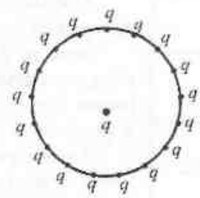
(b) 

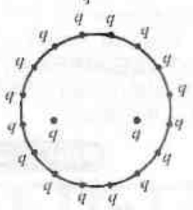
(c) 

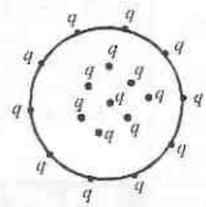
(d) 

3. If 18 charges are to be arranged on a circular region such that the potential energy of the system is minimum then the best arrangement will be

(a) 

(b) 

(c) 

(d) 

4. According to the information given in the passage, if 19 identical point charges are arranged on a circular region such that the potential energy of the system is minimum then, for the arrangement, choose the incorrect statement.

(a) At least three charges will be collinear
(b) At the most five charges can be co-linear
(c) One charge has to occupy the centre
(d) There is at least one charge whose distance from all the other charges is equal

5. Suppose that you are given six identical point charges. You are free to place them anywhere on a circular region of radius r. If each charge is q, the minimum possible value of potential energy of the arrangement will be

(a) zero (b) Kq^2/r

(c) $\frac{3Kq^2}{r}\left(2+\frac{1}{2}+\frac{1}{\sqrt{3}}\right)$ (d) $\frac{6Kq^2}{r}\left(2+\frac{1}{2}+\frac{1}{\sqrt{3}}\right)$

Comprehension - 2 : *Stable and unstable equilibrium*

figure 1

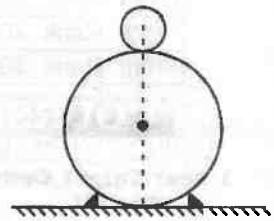


figure 2

A body is said to be in **equilibrium** when the net force acting on it is zero. Suppose that it is displaced slightly from the equilibrium position. After displacement, if the forces act on it in such a way that it is displaced further away from the equilibrium position then it is said that the **equilibrium is unstable**. On the other hand, if the forces act on it in such a way that the body tends to move back to equilibrium position, then we say that the equilibrium is stable. Lastly, if the body neither tends to move away nor towards the equilibrium position, we say that the **equilibrium is neutral**.

For example, if a hemisphere is kept on a flat horizontal plane as shown in figure 1 then it is easy to see that the hemisphere is in stable equilibrium.

On the other hand, if we manage to balance a table-tennis ball over a football as shown in figure 2 then the table-tennis ball will be in unstable equilibrium.

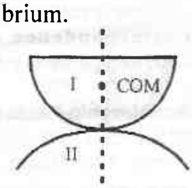


figure 3

Some elementary questions of stability are answered by common sense as seen in above examples. But there is a large variety of questions which may require some mathematical calculations. We will study one such case. Suppose that a body (Body-I) with a curved bottom is balanced on a body (Body-II) with curved top as shown in figure 3. It is given that no slipping is possible between the bodies.

Body-I will be in equilibrium when its centre of mass lies vertically above the point of contact. Let R_1 and R_2 be the radii of curvature of two surfaces at the point of contact. Let the height of centre of mass of body-I be at a height h above the point of contact.

Then it can be mathematically proved that if the upper body is displaced slightly from the equilibrium position, it will be in

Stable equilibrium if $\frac{1}{h} > \frac{1}{R_1} + \frac{1}{R_2}$

Contd. on page no. 60

From 26 and go back.

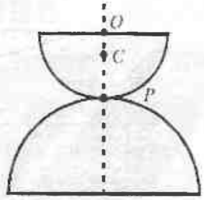
Contd. from page no. 26

Unstable equilibrium if $\frac{1}{h} < \frac{1}{R_1} + \frac{1}{R_2}$

Note that the proof has been avoided here to keep the passage simple.

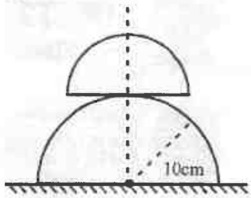
Let us look at some simple examples of the above result.

Example 1 : Suppose that a hemisphere is kept over another hemisphere as shown in figure. It is given that the centre of mass of a uniform solid hemisphere lies at a height $\frac{3r}{8}$ from it's base on it's axis. If the radius of lower hemisphere is 10 cm, for what values of R_1 will the upper hemisphere in stable equilibrium?



Here,

$$h = r - \frac{3r}{8} = \left(\frac{5r}{8}\right), R_2 = 10 \text{ cm}$$



Let $R_1 = r$

So, for stable equilibrium,

$$\frac{8}{5r} > \frac{1}{r} + \frac{1}{10} \Rightarrow \frac{3}{5r} > \frac{1}{10}$$

$\Rightarrow \quad r < 6$ cm.

Example 2 : If the hemisphere in the previous problem is inverted.

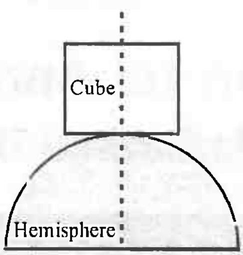
Then, $h = 3r/8$, $R_1 \to \infty$ (for a plane surface) and $R_2 = 10$ cm

So, for stable equilibrium

$8/3r > 1/10 + 1/\infty \qquad \Rightarrow r < \frac{80}{3}$ cm

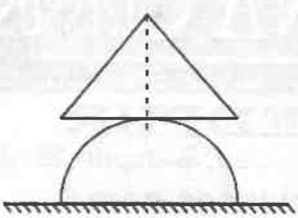
for stable equilibrium of upper hemisphere.

6. A cube of side length a is resting on a hemisphere of radius r. The maximum value of a/r for which the cube will be in stable equilibrium is



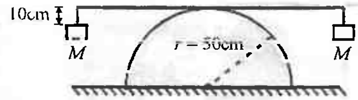
(a) zero
(b) 1
(c) 2
(d) infinity

7. A cone of height 2 cm is balanced on a hemisphere of radius 10 cm. It is given that the centre of mass of a solid uniform cone lies at a height $h/4$ above its base. The cone will be in



(a) stable equilibrium (b) unstable equilibrium
(c) neutral equilibrium
(d) stable or unstable equilibrium depending on the radius of the circular base

8. Two equal point masses M each are suspended from a thin rod of mass $2M$ and length 100 cm. The rod is placed in equilibrium on a hemisphere of radius 50 cm. For checking the equilibrium, the value of h in formula



$$\frac{1}{h} >< \frac{1}{R_1} + \frac{1}{R_2}$$

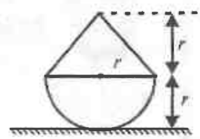
derived in the passage should be kept as

(a) $h = 0$ (b) $h = -10$ cm
(c) $h = 10$ cm (d) $h = -5$ cm

9. The arrangement described in Q.8 will be in

(a) stable equilibrium (b) unstable equilibrium
(c) neutral equilibrium (d) half stable equilibrium

10. A cone of height r and base radius also r is stuck on the flat surface of a hemisphere, also of radius r. The arrang ement is placed on a horizontal plane as shown in figure. The arrangement will be in



(a) stable equilibrium (b) unstable equilibrium
(c) neutral equilibrium
(d) stable / unstable equilibrium depending on what my partner thinks

Section-II (Q.No. 11 to 15)
Match the columns

11.

Column I	**Column II**
(a) Velocity at $t = 0$ of a particle following the equation $x = u(t - 8) + \alpha(t - 2)^2$	(P) α
(b) Acceleration of a particle moving according to equation $x = 4(t - 5) + \alpha(t - 2)^2$ at $t = 0$	(Q) 2α
(c) Velocity of the particle moving according to equation $x = ut + 5\alpha t^2 \ln(1 + t/2) + \alpha t^2$ at $t = 0$	(R) u
(d) Acceleration of the particle moving according to the equation $x = ut + 5\alpha t^2 \ln(1 + t/2) + \alpha t^2$	(S) $u - 4\alpha$

12. A person A can swim in still water with a velocity 5 m/s. If the water is flowing at a speed 3 m/s and if

Column I	Column II
(a) The man swims in a direction perpendicular to the flow of river in frame of river then	(P) he will cover a drift in the direction of river
(b) The man swims at an angle of 150° to the direction of the flow of river in river frame then	(Q) he will cover zero drift
(c) The man swims at an angle of 53° to the direction of flow of river in river frame then	(R) he will cover drift in a direction opposite to the rivers flow
(d) The man swims at an angle 90° to the flow of river, in ground frame then	(S) he will take minimum possible time to cross the river

13. A projectile is thrown at an angle θ with the horizontal with a initial velocity v_0. If the magnitude of velocity of the projectile and time are related as

$$\frac{v^2(t)}{a^2} - \left(t - \frac{b}{a}\right)^2 = \frac{c^2}{a^2}\text{, then}$$

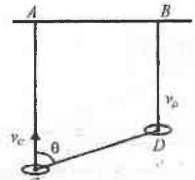
Column I	Column II
(a) Range is	(P) c
(b) Height is	(Q) $2b/a$
(c) Time of flight is	(R) $2bc/a$
(d) Velocity at highest point	(S) $b^2/2a$

14. A particle moving in horizontal plane along a curve whose equation in polar co-ordinates is $r = 2a\cos\theta$

Column I	Column II
(a) If $d\theta/dt = 5$ rad/s and $\theta = 60°$, then	(P) $a_N = \frac{100a}{\sqrt{3}}(1+\sqrt{2})$ m/s^2
(b) If $v = 10a$ m/s and $\theta = 30°$, then	(Q) $a_T = \frac{50\theta a}{\sqrt{3}}$ m/s^2
(c) If $\frac{d^2\theta}{dt^2} = \frac{25}{\sqrt{3}}$ and $\theta = 45°$, then	(R) $a_N = 100a$ m/s^2
(d) If $\omega = 10$ rad/s and $\theta = \pi/2$ rad, then	(S) $a_T = \frac{50a}{2+\sqrt{3}}$ m/s^2
	(T) $a_T = 0$ m/s^2

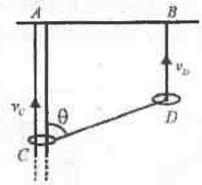
15. In the given systems 2 beads each of mass m are constrained to move only in vertical direction. Match the corresponding constraint relations for the system shown in the left column

(a)



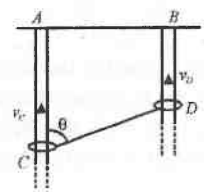
(P) $v_B = 0$

(b)



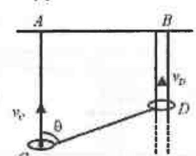
(Q) $v_B = v_C$

(c)



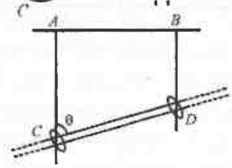
(R) $v_B = -v_C \tan^2\theta/2$

(d)



(S) $v_B = -v_C(\sec\theta - 1)$

(e)

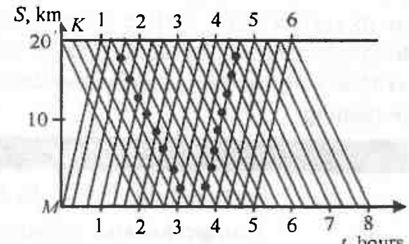


(T) $v_C = v_B(1 + \sec\theta)$

Section-III (Q. No. 16 to 20)

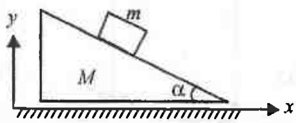
Subjective Questions

16. Two landing-stages M and K are served by launches that all travel at the same speed relative to the water. The distance between the landing-stages is 20 km. It is covered by each launch from M to K in one hour and from K to M in two hours. The launches leave the two landing-stages at the same time at an interval of

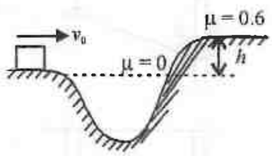


20 minutes and stop at each of them also for 20 minutes. Determine (i) the number of launches in service (ii) the number of launches met by a launch travelling from M to K (iii) the number of launches met by a launch travelling from K to M.

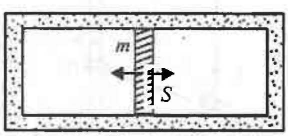
17. A block of mass m is placed on a wedge of mass M as shown in figure. Find the accelerations of the block and the wedge in the reference system fixed to the table, and the reaction. Friction is to be neglected. Analyse the limiting case when the wedge remains stationary.



18. In figure, a block slides along a track from one level to a higher level, by moving through an intermediate valley. The track is frictionless until the block reaches the higher level. There a frictional force stops the block in a distance d. The block's initial speed v_0 is 6 m/s, the height difference h is 1.1 m and the coefficient of kinetic friction μ is 0.6. Find d.



19. In a cylinder filled up with ideal gas and closed from both ends there is a piston of mass m and cross-sectional area S. In equilibrium the piston divides the cylinder into two equal parts each with volume V_0. The gas pressure is P_0. The piston was slightly displaced from the equilibrium position and released. Find its oscillation frequency, assuming the processes in the gas to be adiabatic and the friction negligible.



20. A hemispherical bowl of radius R is set rotating about its axis of symmetry which is kept vertical. A small block kept in the bowl rotates with the bowl without slipping on its surface if the surface of the bowl is smooth and the angle made by the radius through the block with the vertical is θ, find the angular speed at which the bowl is rotating.

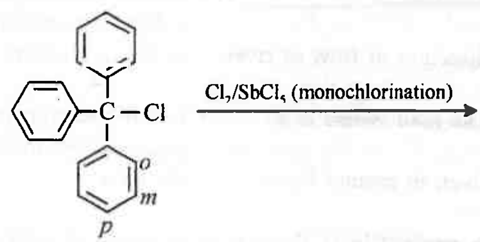
CHEMISTRY

Section I (Q. No. 21 to 33)

Comprehensive questions

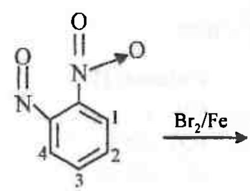
Comprehension I : In monosubstituted benzene derivatives, if the substituent group provides electron density to the ring by its resonance effect, it is always *ortho*/*para* directing. The arenes (alkyl benzenes) stabilize the arenium ion by +I and hyperconjugative effect so are also activating and *ortho*/*para* directing. If the substituent group withdraws electron density by resonance effect then it is *meta* directing. In case of disubstituted benzenes, the strongly activating group dominates over weakly activating or deactivating groups in deciding the orientation of major product. There is often little substitution between two groups that are *meta* to each other due to steric crowding.

21. In the following reaction the monochlorination mainly takes place at



(a) *ortho* position
(b) *meta* position
(c) *para* position
(d) both *ortho* and *para* position

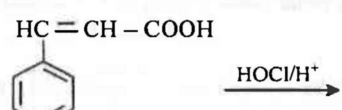
22.



; The major substitution is taking place at position

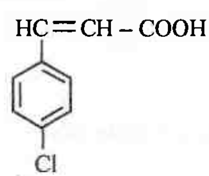
(a) 1 (b) 2 (c) 3 (d) 4.

23.

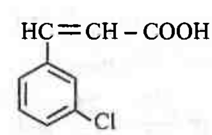


The major product is

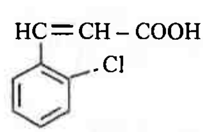
(a)



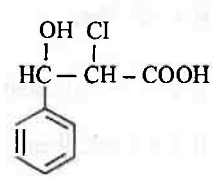
(b)



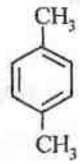
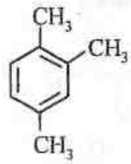
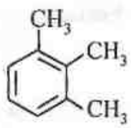
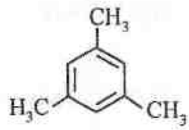
(c)

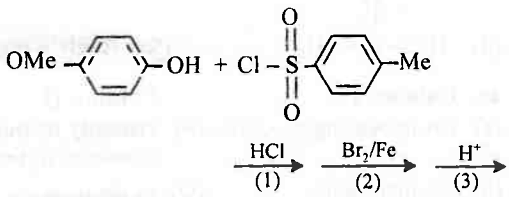


(d)

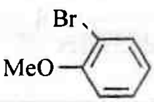
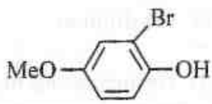
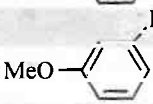
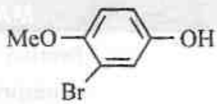


24. Which of the following aromatic ring is most basic with DF/BF_3?

(a) 
(b) 
(c) 
(d) 

25. 

The major product is

(a) 
(b) 
(c) 
(d) 

Comprehension-2

Standard reduction potentials (SRP) for different systems can be used to decide the spontaneity of a reaction *e.g.* $E°_{Zn^{2+}/Zn} = -0.76$ V, hence for the reaction $Zn + 2H^+ \rightarrow Zn^{2+} + H_2$, $\Delta G°$ is negative. It has been found experimentally that if (SRP of an oxidant – SRP of a reductant) is more than 1.7 V, then their combination may lead to explosion (though it may be prevented by kinetic factors). Now go through the following data and answer the questions.

Data:

$E°_{Ag^+/Ag} = 0.80$ V ; $E°_{N_2/N_3^-} = -3.09$ V

$E°_{ClO_4^-/ClO_3^-} = 1.23$ V ; $E°_{Na^+/Na} = -2.71$ V

$E°_{Fe^{3+}/Fe^{2+}} = 0.77$ V ; $E°_{O_2/H_2O_2} = -1.03$ V

$E°_{H_2O_2/H_2O} = 1.76$ V ; $E°_{O_3/O_2} = 2.07$ V

$E°_{MnO_4^-/Mn^{2+}} = 1.54$ V ; $E°_{Cr_2O_7^{2-}/Cr^{3+}} = 1.33$ V

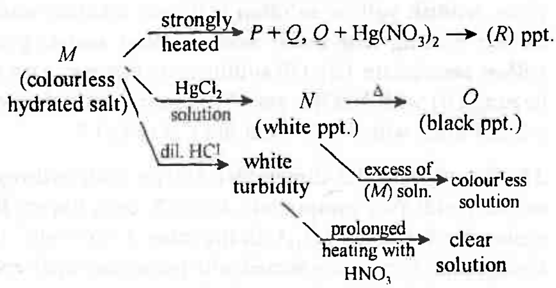
26. Which of the following ionic combinations may lead to the formation of explosive substance?
(a) Silver ion and azide ion
(b) Sodium ion and azide ion
(c) Silver ion and perchlorate ion
(d) All of these.

27. Which of the following ions will be capable of causing catalytic decomposition of H_2O_2?
(a) Fe^{3+} (b) Fe^{2+}
(c) Both (a) and (b) (d) None of these

28. Which statement about standard reduction potentials is correct?
(a) $E°_{D^+/D_2}$ = zero at 298 K
(b) $E°_{H^+/H_2}$ = zero at all temperatures
(c) A redox reaction is feasible if sum of SRP of oxidant and that of reductant is a positive quantity
(d) $K_2Cr_2O_7$ (acid) is stronger oxidising agent than $KMnO_4$ (acid).

29. Which is correct about the reaction between H_2O_2 and O_3?
(a) O_3 will oxidise H_2O_2 into O_2
(b) It is a case of mutual reduction
(c) It is not a redox reaction
(d) H_2O_2 being a stronger oxidising agent will decompose ozone into oxygen.

Comprehension - 3



31. The colour of the compound R is
(a) white (b) yellow
(c) black (d) brown

32. The structure of compound P is
(a) linear (b) crown shaped
(c) square pyramidal (d) zig-zag chain

33. Compound M is used
(I) in photography (II) in analytical chemistry
(III) as a dehydrating agent
(IV) as an oxidising as well as reducing agent
Choose the correct option.
(a) I, III (b) I, II and III
(c) I, II (d) I, II, III and IV.

Section-II (Q. No. 34 to 37)

Subjective Problems

34. Rate of a reaction $A + B \rightarrow$ product is given as a function of different initial concentrations of A and B.

$[A]$/mol L^{-1}	$[B]$/mol L^{-1}	r_0/mol L^{-1} min^{-1}
0.01	0.01	0.005
0.02	0.01	0.010
0.01	0.02	0.005

Determine the order of the reaction with respect to A and with respect to B. What is the half-life of A in the reaction?

35. Calculate the concentration of ammonium ion that is required to prevent the precipitation of $Mg(OH)_2$ in a solution with $[Mg^{2+}] = 0.10$ M and $[NH_3] = 0.10$ M. Two equilibria are involved in this system.

$$Mg(OH)_{2(s)} \rightleftharpoons Mg^{2+}_{(aq)} + 2OH^-_{(aq)} \quad K_{sp} = 1.5 \times 10^{-11} \quad \text{... (i)}$$

$$NH_{3(aq)} + H_2O_{(l)} \rightleftharpoons NH_4^+{}_{(aq)} + OH^-_{(aq)} \quad K_{sp} = 1.8 \times 10^{-5} \quad \text{... (ii)}$$

36. A well known orange crystalline compound (A) when burnt imparts violet colour of flame. (A) on treating with (B) and concentrated H_2SO_4 gives reddish gas (C) which gives reddish yellow solution (D) with alkaline water. (D) on treating with acetic acid and lead acetate gives yellow precipitate (E). (B) sublimes on heating. Also on heating (B) with NaOH, gas (F) is formed which gives white fumes with HCl. What are (A) to (F) ?

37. Reaction of 3,3-dimethyl-1-butene with hydrogen iodide yields two compounds A and B, each having the molecular formula $C_6H_{13}I$, in the ratio $A : B = 90 : 10$. Compound A, on being heated with potassium hydroxide in n-propyl alcohol, gives only 3,3-dimethyl-1-butene. Compound B undergoes elimination under these conditions to give 2,3-dimethyl-2-butene as the major product. Suggest structures for compounds A and B.

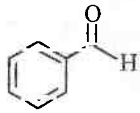
Section-III (Q. No. 38 to 40)

Match the columns

38.

Column I	Column II
(a) Isothermal vaporisation of water at 100°C	(P) $\Delta T = 0$
(b) Isothermal reversible expansion of an ideal gas	(Q) $\Delta E = 0$
(c) Adiabatic compression of an ideal gas	(R) $\Delta H = 0$
(d) Adiabatic free expansion of ideal gas	(S) $Q = 0$

39. Which compounds in column (I) shows a characteristic test with reagents in column (II)?

Column I	Column II
(a) 	(P) Tollen's reagent
(b) $H_3C-\overset{\overset{\displaystyle O}{\|}}{C}-H$	(Q) Fehling's solution
(c) $H_3C-\overset{\overset{\displaystyle O}{\|}}{C}-NH_2$	(R) NaOH + I_2
(d) $H_3C-\overset{\overset{\displaystyle O}{\|}}{C}-CH_3$	(S) Brady's reagent

40.

Column I	Column II
(a) On increasing pressure	(P) viscosity of liquid increases, ρ_L increases
(b) On increasing temperature	(Q) V_L decreases, ρ_L decreases
(c) On dilution	(R) viscosity of water decreases
(d) On increasing mass	(S) none of these

MATHEMATICS

Section I (Q. No. 41 to 52)

Comprehensive questions

Comprehension -1 : If $f(x) = (x - \alpha)^n g(x)$ then $f(\alpha) = f'(\alpha) = f''(\alpha) = ... = f^n(\alpha) = 0$ where $f(x)$ and $g(x)$ are polynomials.

For a polynomial $f(x)$ with rational coefficients, answer the following questions.

41. If $f(x)$ is of degree 4 and touches x-axis at $(\sqrt{3}, 0)$, then

(a) sum of the roots $f(x)$ is 0

(b) product of the roots of $f(x)$ is 9

(c) sum of the product of the roots taken three at time is $12\sqrt{3}$

(d) none of these.

42. If $f(x)$ is of degree 3 and touches x-axis, then

(a) all the roots of $f(x)$ are rational

(b) only one root is rational

(c) both (a) and (b) may be possible

(d) none of these.

43. If $f(-3) = f(2) = 0$ and $f'(-3) < 0$, then the largest intergal value of C is (where $f(x) = x^3 + ax^2 + bx + c$),

(a) -18 (b) -19 (c) -12 (d) -6.

44. $f(\alpha) = f'(\alpha) = f''(\alpha) = 0, f(\beta) = f'(\beta) = f''(\beta) = 0$ and $f(x)$ is polynomial of degree 6, then

(a) all the roots of $f''(x) = 0$ are real
(b) atleast two roots of $f''(x) = 0$ are always real
(c) exactly two roots of $f''(x) = 0$ are real
(d) none of these

Comprehension -2 : Consider a three dimensional cartesian system with origin at O and three rectangle coordinate axes x, y and z - axis. Suppose that the distance between two points P and Q in the space having their coordinates (x_1, y_1, z_1) and (x_2, y_2, z_2) respectively be defined by the following formula

$$d(P \cdot Q) = |x_2 - x_1| + |y_2 - y_1| + |z_2 - z_1|.$$

Although the formula of distance between two points has been defined in a new way, yet the other definitions remain same (like section formula, direction cosines etc.) So in general equations of straight line in space plane in space remain unchanged.

45. If l, m, n represent direction cosines (if we can call it) of a vector $\overline{OP}$, then which of the following relations holds?

(a) $l^2 + m^2 + n^2 = 1$ (b) $l + m + n = 1$
(c) $|l + m + n| = 1$ (d) $|l| + |m| + |n| = 1$.

46. Locus of point P if $d(O, P) = k$ where k is a positive constant number, represents

(a) a sphere of radius k
(b) a set of eight planes forming an octahedron
(c) a set of eight planes forming hexagonal prism
(d) an infinite cylinder of radius k.

47. Let A be a point (5,2,3) in the given reference system. Then locus of the point P in the first octant satisfying the equation $d(OP) = d(A, P)$ does not contain

(a) any of the coordinates axes
(b) any of the coordinates planes
(c) any plane parallel to coordinates axes
(d) any plane parallel to coordinates planes.

48 An equilateral triangle has its vertices on the axes of coordinates and area $\sqrt{3}$ square units. The coordinates of the orthocentre of the triangle are

(a) (1, 1, 1) (b) $\left(\frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}\right)$

(c) $\left(\frac{1}{3}, \frac{1}{3}, \frac{1}{3}\right)$ (d) $\left(\frac{\sqrt{2}}{3}, \frac{\sqrt{2}}{3}, \frac{\sqrt{2}}{3}\right)$

49. Let $OABC$ represent a regular tetrahedron with edge length $2a$ and vertices A, B, C lying on x, y and z-axis repectively. Let P be a point inside the region of the tetrahedron satisfying

$$d(O, P) \le \min\{d(P, A), d(P, B), d(P, C)\}$$

The maximum value of $d(O, P)$ is

(a) a (b) $\sqrt{2}a$ (c) $2a/3$ (d) $4a/3$.

Comprehension -3 : *Statement* - In the equation $z^2 + 2\lambda z + 1 = 0$, λ is a parameter which can take any real value, then

50. The roots of this equation lie on a certain circle, if

(a) $-1 < \lambda < 1$ (b) $\lambda > 1$
(c) $\lambda < 1$ (d) none of these.

51. One root lies inside the unit circle and one outside, if

(a) $-1 < \lambda < 1$ (b) $\lambda > 1$
(c) $\lambda < 1$ (d) none of these.

52. For every large value of λ, the roots are approximately

(a) -2λ, $1/\lambda$ (b) $-\lambda$, $-1/\lambda$
(c) -2λ, $-1/\lambda$ (d) none of these.

Section-II (Q. No. 53 to 56)
Subjective Questions

53. Let $f(x)$ = minimum $\{e^x, 3/2, 1 + e^{-x}\}$, $0 < x < 1$. Find the area bounded by $y = f(x)$, x-axis, y-axis and the line $x = 1$

54. Tangents PA and PB are drawn to circle $(x + 3)^2 + (y - 2)^2 = 1$ from point P lying on $y^2 = 4x$, then find the locus of circumcentre of ΔPAB.

55. Find the minimum value of

$$P(A \cup B) \text{ if } P(B) = \{P(A \cup B)\}^2$$

56. If $x = \sin\frac{2\pi}{7} + \sin\frac{4\pi}{7} + \sin\frac{8\pi}{7}$

and $y = \cos\frac{2\pi}{7} + \cos\frac{4\pi}{7} + \cos\frac{8\pi}{7}$, then find $x^2 + y^2$

Section-III (Q. No. 57 to 60)
Match the columns

57. Let $f(x)$ be a real valued function defined by $f(x) = x^2 - 2|x|$ and

$$g(x) = \begin{cases} \text{minimum}\{f(t): -2 < t < x\}, x \in [-2, 0) \\ \text{maximum}\{f(t): 0 \le t \le x\}, x \in [0, 3] \end{cases}$$

Column I	Column II
(a) $f(x)$ is not continous at x equal to	(P) -2
(b) $g(x)$ is not derivable at x equal to	(Q) 0

(c) Number of points of local extremum of $g(x)$ is equal to — (R) 1

(d) Absolute maximum value of $g(x)$ is equal to — (S) 2

(T) 3

58. Let $ax + by = 1$ be a chord of the curve $3x^2 - y^2 - 2x + 4y = 0$ intersecting the curve at the points A and B such that AB subtends a right angle at the origin O.

Column I	**Column II**
(a) $a - 2b + 1$ is equal to	(P) 0
(b) the distance from the origin of the farthest chord cannot exceed	(Q) 2
(c) if the triangle OAB is isosceles then the area of the triangle cannot exceed	(R) $\sqrt{5}$
(d) The number of chords such that triangle OAB is isosceles cannot exceed	(S) 3
	(T) 5

59.

Column I	**Column II**
(a) if a, b, c are unequal positive numbers and b is A.M of a and c then the roots of $ax^2 + 2bx + c = 0$ are	(P) of opposite signs
(b) If $a \in R$, then the roots of the equation $x^2 - (a + 1)x - a^2 - 4 = 0$ are	(Q) rational numbers
	(R) real and unequal
(v) If a, b, c are unequal positive numbers and b is H.M. of a and c then the roots of $ax^2 + 2bx + c = 0$ are	(S) imaginary
(d) If $\lvert a \pm b\rvert < c$ and $a = 0$ then the roots of $a^2x^2 + (b^2 + a^2 - c^2)x + b^2 = 0$ are	(T) of same sign

60. Let $f : R - \{0\} \to R$ be defined by

$$f(x) = \frac{x}{e^x - 1} + \frac{x}{2} + 1,$$

now match the entries from the following two columns

Column I	**Column II**
(a) $f(x)$ is even	(P) true
(b) $f(x)$ is one-one	(Q) false
(c) $f(x)$ is onto	(R) can't be decided
(d) $\lim_{x \to 0} f(x) = 2$	(S) data insufficient

ANSWERS

PAPER I

1. (b) 2. (c) 3. (b) 4. (c) 5. (a)
6. (d) 7. (c) 8. (c) 9. (b) 10. (c)
11. (d) 12. (d) 13. (a, b, c, d) 14. (b)
15. (a) 16. (a) 17. (d) 18. (b, c)
19. (a, d) 20. (b, c) 21. (d) 22. (d) 23. (a)
24. (b) 25. (c) 26. (d) 27. (c) 28. (b)
29. (d) 30. (a) 31. (a) 32. (a)
33. (a, c, d) 34. (a, d) 35. (a, b)
36. (c, d) 37. (b, d) 38. (a, c) 39. (a, b)
40. (a, d) 41. (c) 42. (a) 43. (a) 44. (c)
45. (b) 46. (b) 47. (a) 48. (a) 49. (c)
50. (a) 51. (a) 52. (a) 53. (a, d)
54. (a, b, c, d) 55. (c) 56. (b, c)
57. (b, c) 58. (a, b, c, d) 59. (a, b)
60. (a, b)

PAPER II

1. (b) 2. (d) 3. (c) 4. (d) 5. (d)
6. (c) 7. (b) 8. (d) 9. (a) 10. (b)
11. (a)-S (b)-Q (c)-R (d)-Q
12. (a)-P, S ; (b)-R ; (c)-P ; (d)-Q
13. (a)-R ; (b)-S ; (c)-Q ; (d)-P
14. (a)-R, S ; (b)-Q, R ; (c)-P, Q ; (d)-R, T
15. (a)-R ; (b)-S ; (c)-Q ; (d)-T ; (e)-P, Q
16. (i) 11, (ii) 8, (iii) 8
17. $a_x = g\dfrac{M\sin\alpha\cos\alpha}{M + m\sin^2\alpha}$, $b_y = -g\dfrac{(M+m)\sin^2\alpha}{M + m\sin^2\alpha}$
$b_x = -g\dfrac{m\sin\alpha\cos\alpha}{M + m\sin^2\alpha}$. $Q = \dfrac{mMg\cos\alpha}{M + \sin^2\alpha}$
18. 1.17 m
19. $\omega = S\sqrt{2\gamma P_0 / mV_0}$, where γ is the adiabatic exponent
20. $\omega = \sqrt{gR\sec\theta}$
21. (d) 22. (b) 23. (b) 24. (c) 25. (c)
26. (a) 27. (d) 28. (a) 29. (b) 30. (d)
31. (a) 32. (d) 33. (c)
38. (a)-P ; (b)-P, Q, R ; (c)-S ; (d)-P, Q, R, S
39. (a)-P, S ; (b) - P, Q, R, S ; (c)-R ; (d)-R, S
40. (a)-P, R ; (b)-Q, R ; (c)-Q ; (d)-S
41. (b) 42. (a) 43. (b) 44. (a) 45. (d)
46. (b) 47. (d) 48. (c) 49. (a) 50. (a)
51. (b) 52. (c)
53. $\dfrac{\pi}{2}\left(\dfrac{\sin(n)\cdot\sin\left(n - \frac{1}{2}\right)}{\sin\left(\frac{1}{2}\right)}\right)\dfrac{\sqrt{5}-1}{2}$
54. $(y - 1)^2 = 2x + 3$ 55. $\dfrac{\sqrt{5}-1}{2}$ 56. 2
57. (a)-Q ; (b)-Q, S ; (c)-Q, (d)-T
58. (a)-Q ; (b)-R, S, T ; (c)-T ; (d)-S, T
59. (a)-R, T ; (b)-P, R ; (c)-S ; (d)-R, T
60. (a)-P ; (b)-Q ; (c)-Q ; (d)-P

AIIMS | CBSE | DPMT | AFMC | VMMC | EAMCET | WB-JEE | BHU | CMC

2007 Medical Entrance Exam

UP CPMT | CET Karnataka | Manipal PMT | JIPMER

Practice Test Paper

MP PMT | MGIMS | PMDT Bihar | PMT Haryana | Kerala PMT | Raj. PMT | TNPCEE

1. If velocity (V), time (T) and force (F) were chosen as fundamental quantities, the dimension of mass will be

(a) FTV (b) $F^{-1}TV$ (c) FTV^{-1} (d) $FT^{-1}V$.

2. Two trains A and B of length 400 m each are moving on two parallel tracks with a uniform speed of 72 km h^{-1} in the same direction, with A ahead of B. The driver of B decides to overtake A and accelerates by 1 ms^{-2}. If after 50 s, the guard of B just brushes past the driver of A, what was the original distance between them?

(a) 1200 m (b) 1250 m (c) 850 m (d) 450 m.

3. A balloon is rising up with a velocity of 9.8 ms^{-1} and a bag is dropped from it when its height from the ground is 39.2 m. The time taken by the bag to reach the ground is

(a) 2 s (b) 3 s (c) 4 s (d) 5 s.

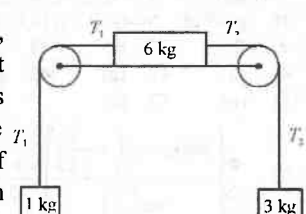
4. The angle between the two vectors $\vec{A} = 3\hat{i} + 4\hat{j} + 5\hat{k}$ and $B = 3\hat{i} + 4\hat{j} - 5\hat{k}$ will be

(a) zero (b) 45° (c) 90° (d) 180°

5. A man standing in a lift holds a spring balance with a load of 5 kg suspended from it. What would be the reading of the balance when the lift is descending with an acceleration of 4 ms^{-2}?

(a) 1 kg (b) 2 kg (c) 3 kg (d) 4 kg.

6. Three masses of 1 kg, 6 kg and 3 kg are connect to each other with strings and are placed on a table as shown in figure. If $g = 10$ ms^{-2}, the acceleration with which the system is moving is



(a) zero (b) 1 ms^{-2} (c) 2 ms^{-2} (d) 3 ms^{-2}.

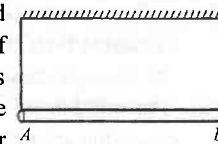
7. A particle is displaced from a position $(2\hat{i} - \hat{j} + \hat{k})$ to another position $(3\hat{i} + 2\hat{j} - 2\hat{k})$ under the action of the force $(2\hat{i} + \hat{j} - \hat{k})$. The work done by the force in arbitrary unit is

(a) 8 (b) 10 (c) 12 (d) 16

8. A 50 gram bullet moving with a velocity of 10 ms^{-1} gets embedded into a 950 g stationary body. The loss in kinetic energy of the system will be

(a) 95% (b) 100% (c) 5% (d) 50%.

9. A uniform rod of mass m and length l is suspended by means of two light inextensible strings as shown in figure. Tension in one string immediately after the other string is cut is



(a) $mg/2$ (b) mg (c) $2mg$ (d) $mg/4$

10. The moment of inertia of a circular ring about one of its diameter is I. What will be its moment of inertia about a tangent parallel to the diameter?

(a) $4I$ (b) $2I$ (c) $(3/2)I$ (d) $3I$.

11. A remote sensing satellite of the earth, revolves in a circular orbit at a height of 250 km above the earth's surface. What is the orbit speed of the satellite? (Take radius of earth R = 6400 km, g = 10 ms^{-2})

(a) 6.8 kms^{-1} (b) 7.8 kms^{-1}
(c) 8.8 kms^{-1} (d) 9.8 kms^{-1}.

12. The rotation period of an earth satellite close to the surface of the earth is 83 minute. The satellite in an orbit at a distance of three times earth radii from its surface will be

(a) 83 minute (b) $83 \times \sqrt{8}$ minute
(c) 664 minute (d) 249 minute.

13. A horizontal pipe line carries water in a streamline flow. At a point along the pipe where the cross-sectional area is 10 cm^2, the water velocity is 1 m/s and the pressure is 2000 Pa. What is the pressure of water at another point where the cross-sectional area is 5 cm^2?

(a) 200 Pa (b) 300 Pa (c) 400 Pa (d) 500 Pa.

14. A steel wire of length 4.7 m and cross section 3.0×10^{-5} m^2 stretches by the same amount as a copper

On putting numerical values, we get

$$\theta = \cos^{-1}\left(1 - \frac{0.2^2}{2\times 9.8\times 9.8}\right) = \cos^{-1}(0.9998) = 1.14^\circ$$

Alternative Method :

$$a = -g\sin\theta \Rightarrow v\frac{dv}{ds} = -g\sin\theta,\ vdv = -g\sin\theta(ld\theta)$$

Integrating, we get $\int_{v_0}^{0} vdv = -gl\int_0^\theta \sin\theta d\theta$

$$= gl\,[\cos\theta]_0^\theta$$

or $\frac{-v_0^2}{2} = gl\,[\cos\theta - 1]$

or $\frac{v_0^2}{2} = gl\,[1-\cos\theta] \Rightarrow \cos\theta = 1 - \frac{v_0^2}{2gl}$

$$\Rightarrow \theta = \cos^{-1}\left(1 - \frac{v_0^2}{2gl}\right)$$

On putting numerical values, we get

$$\theta = \cos^{-1}\left(1 - \frac{0.2^2}{2\times 9.8\times 9.8}\right) = \cos^{-1}(0.9998) = 1.14^\circ$$

7. Given $l_1 - l_2 = 22$ cm and $N_1T_1 = N_2T_2$

$$\Rightarrow N_1 2\pi\sqrt{\frac{l_1}{g}} = N_2 2\pi\sqrt{\frac{l_2}{g}}$$

Squaring both sides, we get $N_1^2 l_1 = N_2^2 l_2$

$$\Rightarrow \frac{l_1}{l_2} = \frac{N_2^2}{N_1^2} = \frac{36^2}{30^2} = \frac{36}{25}$$

$$\Rightarrow \frac{l_1}{l_2} - 1 = \frac{l_1 - l_2}{l_2} = \frac{36}{25} - 1 = \frac{11}{25}$$

$\Rightarrow l_2 = \frac{25}{11}\times 22 = 50$ cm So, $l_1 = l_2 + 22 = 72$ cm

8. Given $v = 250$ m/s, $\upsilon = 500$ Hz and $\Delta\phi = 60^\circ$.

$$\Rightarrow \lambda = \frac{v}{\upsilon} \text{ and } \Delta\phi = \frac{2\pi}{\lambda}\Delta x \Rightarrow \Delta x = \frac{\lambda}{2\pi}\Delta\phi = \frac{v}{2\pi\upsilon}\Delta\phi$$

On putting numerical values, we get

$$\Delta x = \frac{250}{2\pi(500)}\left(\frac{\pi}{3}\right) = \frac{1}{12}\text{ m}$$

9. $v = \sqrt{\gamma P/\rho}$

The density of mixture is given by

$$\rho' = \frac{V_1\rho_1 + V_2\rho_2}{V_1 + V_2} = \frac{4(1)+1(16)}{5} = 4$$

$$\therefore \frac{v'}{v} = \sqrt{\frac{\rho}{\rho'}} = \sqrt{\frac{1}{4}} = \frac{1}{2} \quad \therefore v' = \frac{1300}{2} = 650 \text{ m/s}$$

10. υ_1 = frequency of closed pipe $= \frac{v}{4l_1} = \frac{v}{60}$.

υ_2 = frequency of open pipe $= \frac{v}{2l_2} = \frac{v}{61}$, *i.e.*, $\upsilon_1 > \upsilon_2$

According to question, $\upsilon_1 - \upsilon_2 = 6$

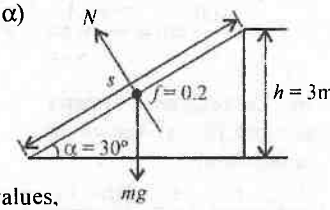
$$\Rightarrow \frac{v}{60} - \frac{v}{61} = 6 \Rightarrow v\left[\frac{61-60}{60(61)}\right] = 6 \Rightarrow v = 6(60)(61)\text{ cm/s}$$

$$\therefore \upsilon_1 = \frac{v}{60} = \frac{6(60)(61)}{60} = 366\text{ Hz and}$$

$$\therefore \upsilon_2 = \frac{v}{61} = \frac{6(60)(61)}{61} = 360\text{ Hz}$$

11. Work done by friction is given by

$W = -fNs = -f(mg\cos\alpha)$



$\frac{h}{\sin\alpha}\left[\text{As } \sin\alpha = \frac{h}{s}\right]$

$W = -fmgh\cot\alpha$

On putting numerical values,

we get $W = -0.2(100)(9.8)(3)\cot 30^\circ = -1018.44$ J

Change in the internal energies of the body and the plane $= -W = 1018.44$ J $= 1.01$ kJ.

12. At $t = 50^\circ$ C, $\rho_{body\,(50^\circ C)} = \rho_{liquid\,(50^\circ C)} = \rho$ (say).

At $t = 0^\circ$C, $\rho_{b\,(0^\circ C)} = \rho_{b\,(50^\circ C)}(1 + 50\beta_b)$

$\rho_{l\,(0^\circ C)} = \rho_{l\,(50^\circ C)}(1 + 50\beta_l)$

$\therefore$ fraction of body immerged,

$$\delta = \frac{\rho_b}{\rho_l} = \frac{1+50\beta_b}{1+50\beta_l} = (1 + 50\beta_b)(1 + 50\beta_l)^{-1}$$

$\approx (1 + 50\beta_b)(1 - 50\beta_l) \approx [1 - 50(\beta_l - \beta_b)]$

$= 1 - 50 \times 7.7 \times 10^{-5} = 0.996$

13. From first law of thermodynamics

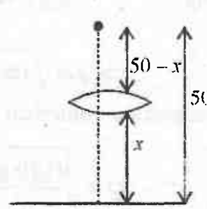
$dQ = dU + dW = nC_VdT + PdV = nC_VdT + nRdT$

$dQ = n(C_V + R)\,dT = nC_PdT \Rightarrow dQ = \frac{5}{2}nRdT = \frac{5}{2}PdV$

On putting numerical values, we get

$$Q = \frac{5}{2}\times 1.52\times 10^5\,(0.07 - 0.03) = 1.52 \times 10^4 \text{ J}$$

14. Let the distance of lens from table $= x$,



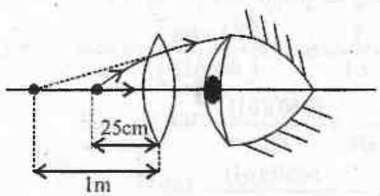
$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$\Rightarrow \frac{1}{+x} - \frac{1}{-(50-x)} = \frac{1}{+8}$$

$$\frac{(50-x)+x}{x(50-x)}=\frac{1}{8}\Rightarrow 400=50x-x^2\Rightarrow x^2-50x+400=0$$

$\Rightarrow (x-40)(x-10)=0 \therefore x = 40$ cm or 10 cm.

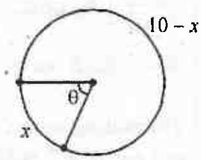
15.



$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}\Rightarrow\frac{1}{f}=\frac{1}{-100}-\frac{1}{-25}=\frac{1}{25}-\frac{1}{100}\Rightarrow\frac{1}{f}=\frac{4-1}{100}$$

$$\therefore f=+\frac{100}{3}\text{ cm}=+\frac{1}{3}\text{m}\Rightarrow \therefore P=\frac{1}{f}=+3\text{D}$$

16. Let resistance of parts as x and $10-x$. According to question.



$$\frac{1}{x}+\frac{1}{10-x}=\frac{1}{1}\Rightarrow\frac{(10-x)+x}{x(10-x)}=1$$

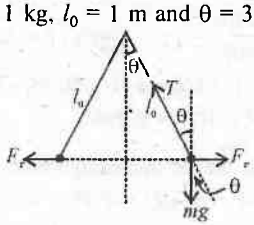
$\Rightarrow \quad 10=10x-x^2\Rightarrow x^2-10x+10=0$

$$\therefore x=\frac{-(-10)\pm\sqrt{100-40}}{2}=\frac{10\pm2\sqrt{15}}{2}=5\pm\sqrt{15}$$

$\Rightarrow \quad x_1 = 8.873\Omega$ and $x_2 = 1.127\Omega$

The connecting wires divide the length in the ratio of $8.873 : 1.127 = 7.87 : 1$

17. Given $m = 1$ kg, $l_0 = 1$ m and $\theta = 30°$



In equilibrium of the charges $mg = T\cos\theta$ ... (i)

$F_e = T\sin\theta$ ... (ii)

Dividing equation (ii) by (i), we get

$$\frac{F_e}{mg}=\tan\theta\Rightarrow\frac{1}{mg}\left(\frac{1}{4\pi\varepsilon_0}\frac{Q^2}{(l_0\sin\theta+l_0\sin\theta)^2}\right)=\tan\theta$$

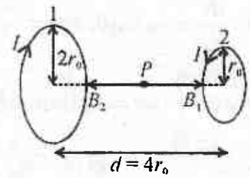
$$\Rightarrow Q=\sqrt{4\pi\varepsilon_0(mg)(4l_0^2\sin^2\theta)\tan\theta}$$

On putting numerical values, we get

$$Q=\sqrt{\frac{(1)(9.8)4(1^2)(\sin^2 30°)(\tan 30°)}{9\times10^9}}$$

$$Q=\sqrt{\frac{(1)(9.8)4(1^2)\left(\frac{1}{4}\right)\left(\frac{1}{\sqrt3}\right)}{9\times10^9}}=\sqrt{\frac{9.8}{\sqrt3(9\times10^9)}}=2.5\times10^{-5}\text{C}$$

18.



$$B_1=\frac{\mu_0 I}{4\pi}\frac{\{2\pi(2r_0)^2\}}{(4r_0^2+4r_0^2)^{3/2}}=\frac{\mu_0 I}{2}\frac{4r_0^2}{16\sqrt2 r_0^3}=\frac{\mu_0 I}{2r_0}\frac{1}{4\sqrt2}$$

$$B_2=\frac{\mu_0 I}{2}\frac{r_0^2}{5\sqrt5 r_0^3}=\frac{\mu_0 I}{2}\frac{1}{5\sqrt5 r_0}$$

$\because \quad B_1 > B_2$

$$B_P=B_1-B_2=\frac{\mu_0 I}{2r_0}\left[\frac{1}{4\sqrt2}-\frac{1}{5\sqrt5}\right]\text{ tesla}$$

19. $N = N_0e^{-\lambda t}$

$$\frac{7}{100}N_0=N_0e^{-\lambda t}\ [\text{where } t=60\text{ hrs.}]\Rightarrow\frac{100}{7}=e^{\lambda t}$$

$$\ln\frac{100}{7}=\lambda t \quad \text{... (i)}$$

Similarly $\ln 2 = 1\,\lambda T_{1/2}$ ... (ii)

Divide equation (ii) by (i), we get $\dfrac{T_{1/2}}{t}=\dfrac{\ln 2}{\ln\frac{100}{7}}$

$$\therefore\ T_{1/2}=\frac{\ln 2}{\ln\frac{100}{7}}(60)\text{ hrs.}=15.64\text{ hrs.}$$

20. From quantization of angular momentum.

$$mvr=\frac{nh}{2\pi} \quad \text{... (i)}$$

From Newton's second law.

$$\frac{1}{4\pi\varepsilon_0}\cdot\frac{Ze^2}{r^2}=m\left(\frac{v^2}{r}\right)$$

$$\Rightarrow mv^2=\frac{e^2}{4\pi\varepsilon_0 r}\ \text{(For hydrogen atom } Z=1) \ \text{...(ii)}$$

From (i) and (ii), we get $\dfrac{mv^2}{mvr}=\dfrac{e^2}{4\pi\varepsilon_0 r}\cdot\dfrac{2\pi}{h}\Rightarrow v=\dfrac{e^2}{2\varepsilon_0 h}$

On putting numerical values, we get

$$v=\frac{(1.6\times10^{-19})^2}{2(8.85\times10^{-12})(6.6\times10^{-34})}=2.19\times10^6\text{ m/s}$$

❖

SOLVED PAPER
BIHAR CECE - 2006
MAINS

QUESTIONS

1. A train passes an observer standing on a platform. The first carriage of the train passes the observer during time t_1 = 1s and the second, during time t_2 = 1.5 s. Find the velocity of the train at the beginning and end of observation and its acceleration, assuming that the motion of the train is uniformly variable. The length of each carriage is l = 12 m.

2. A bullet is fired from a gun from the bottom of a hill along its slope. The slope of the hill is 30° and the angle of the gun to the horizontal is 60°. The initial velocity of the bullet is 21 m/s. Find the distance from the gun to the point at which the bullet falls.

3. A helicopter ascends with a velocity v_0 = 10 m/s. At a height H = 50 m, a heavy body is dropped from it. With what velocity does this body reach the ground?

4. Find the velocity of an artificial satellite moving in a circular orbit at a height h = 1600 km above the surface of the earth. The radius of the earth R = 6400 km.

5. A car of mass M = 1000 kg decelerates from a velocity v = 100 km/h to a stop in 10 s. At what average rate must the braking surfaces lose heat if their temperature is not to rise significantly?

6. A pendulum of length l =9.8 m hangs in equilibrium and is then given velocity v_0 = 0.2 m/s at its lowest point. What is the amplitude of the subsequent oscillation?

7. Two pendulums whose lengths differ by $l_1 - l_2$ = 22 cm oscillate at the same place so that one of them makes N_1 = 30 oscillations and the other N_2 = 36 oscillations during the same time. Find the lengths of the pendulum.

8. The speed of a wave is 250 m/s and its frequency is 500 cycles/s. What is the distance between two points having a phase difference of 60° ?

9. The velocity of sound in hydrogen is 1300 m/s. What will be the velocity in a mixture of 4 parts by volume of hydrogen and 1 part of oxygen at the same temperature and pressure?

10. Two tuning forks A and B give 6 beats/second. A resonates with a closed column of air 15 cm long and B with an open column 30.5 cm long. Calculate their frequencies.

11. A body of mass m = 100 kg slides down an inclined plane with a slope α = 30°. What is the change in the internal energies of the body and the plane upon the displacement of the body by a distance h = 3 m along the vertical? The coefficient of sliding friction is f = 0.2.

12. A solid body floats in a liquid at temperature t = 50°C being completely submerged in it. What fraction δ of the volume of the body is submerged in the liquid after its cooling to t_0 = 0°C, if the coefficient of cubic expansion for the solid is $\beta_s = 0.3 \times 10^{-5}\ K^{-1}$ and of liquid $\beta_l = 8 \times 10^{-5}\ K^{-1}$?

13. Two molecules of an ideal monatomic gas expand isobarically from an initial volume $V_1 = 0.03\ m^3$ to a final volume $V_2 = 0.07\ m^3$. The pressure throughout is $P = 1.52 \times 10^5\ N/m^2$. Calculate the total amount of heat Q absorbed in the process.

14. A point light source is at a height h = 50 cm above a table. An experimenter wishes to obtain a sharp image of the source at the table, using a converging lens of focal length f = 8 cm. At what height should she place the lens?

15. The distance of best vision for an eye is L = 1 m. Find the optical power of the spectacles compensating the defect of vision for this eye.

16. A ring is made of a wire having a resistance R_0 = 10Ω. Find the points at which current-carrying conductors should be connected so that the resistance R between these points is equal to 1Ω.

17. Two masses m = 1 kg with equal charges Q are

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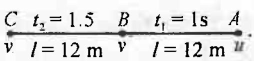
suspended by light strings of length $l_0 = 1$ m from a point. The strings hang at 30° to the vertical what is the value of Q ?

18. Parallel loops of radii r_0, $2r_0$ are at distance $d = 4r_0$ apart and carry currents I in opposite senses. Find the magnetic field B_p at the point P halfway between the loops.

19. A sample of sodium containing a certain concentration of the $_{11}Na^{24}$ isotope is prepared. After 60 hours this concentration has fallen to 7% of its original value. Calculate the half-life of $_{11}Na^{24}$.

20. Determine the velocity of an electron in the first orbit of hydrogen atom.

SOLUTIONS

1. 

For uniform acceleration, $S = \left(\dfrac{u+v}{2}\right)t$

For first carriage $12 = \left(\dfrac{u+v'}{2}\right)1 \Rightarrow u + v' = 24$ ...(i)

For second carriage $12 = \left(\dfrac{v'+v}{2}\right)1.5 \Rightarrow v + v' = 16$ ...(ii)

For first and second carriage both

$24 = \left(\dfrac{u+v}{2}\right)(2.5) \Rightarrow u + v = 19.2$ ...(iii)

Substracting equation (ii) from (i) we get

$u - v = 8$ ...(iv)

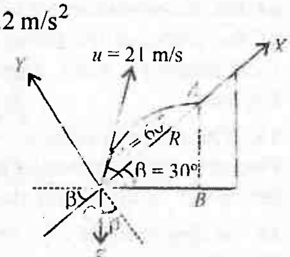
Adding equations (iii) and (iv), we get

$u = \dfrac{19.2+8}{2} = 13.6$ m/s

From equation (iii), we get $v - 19.2 - 13.6 = 5.6$ m/s.

$a = \dfrac{v-u}{t} = \dfrac{5.6-13.6}{2.5} = -3.2 \text{ m/s}^2$

2. By taking y-components of 2nd equation of motion, we get



$S_y = u_y t + \frac{1}{2}a_y t^2$,

$0 = u\sin(\alpha-\beta)t - \frac{1}{2}(g\cos\beta)t^2$, $t = \dfrac{2u\sin(\alpha-\beta)}{g\cos\beta}$.

Horizontal displacement is given by $S_H = u_H t = (u\cos\alpha)t$

$S_H = \dfrac{2u^2\sin(\alpha-\beta)\cos\alpha}{g\cos\beta}$

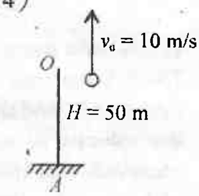
In ΔOAB, $\cos\beta = \dfrac{OB}{OA} = \dfrac{S_H}{R}$,

$R = \dfrac{S_H}{\cos\beta} = \dfrac{2u^2\sin(\alpha-\beta)\cos\alpha}{g\cos^2\beta}$

On putting numerical values, we get

$$R = \frac{2(21^2\sin 30°\cos 60°)}{9.8\cos^2 30°} = \frac{2(21^2)\left(\frac{1}{2}\right)\left(\frac{1}{2}\right)}{9.8\left(\frac{3}{4}\right)} = 30 \text{ m}$$

3. From 3rd equation of motion,



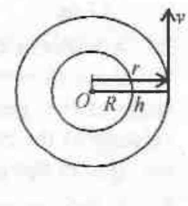
$v^2 = u^2 + 2aS$

$\Rightarrow v^2 = v_0^2 + 2gH$, $v = \sqrt{v_0^2 + 2gH}$

On putting numerical values, we get

$v = \sqrt{10^2 + 2(9.8)(50)} = 32.86$ m/s.

4. From Newton's law of gravitation, $F = \dfrac{GMm}{r^2}$ ... (i)



From dynamics of circular motion, $F = \dfrac{mv^2}{r}$ ... (ii)

From equations (i) and (ii), we get

$\dfrac{GMm}{r^2} = \dfrac{mv^2}{r}$, $v = \sqrt{\dfrac{GM}{r}} = \sqrt{\dfrac{GM}{R+h}} = \sqrt{\dfrac{gR^2}{R+h}}$

On putting numerical values, we get

$v = \sqrt{\dfrac{9.8(6.4\times10^6)^2}{(6400+1600)10^3}} = 7.08$ km/s

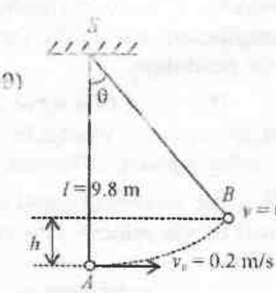
5. From work-energy theorem,

$W = \frac{1}{2}M(v'^2 - v^2) = \frac{1}{2}\times1000\left(0^2 - \frac{500^2}{18^2}\right) = -3.85\times10^5$

Average rate of heat loss

$= \dfrac{\Delta W}{\Delta t} = \dfrac{3.85\times10^5}{10} = 3.85\times10^4$ J/s $= 38.5$ kW

6. From conservation of mechanical energy



$\frac{1}{2}mv_0^2 = mgh = mg(l - l\cos\theta)$

$= mgl(1 - \cos\theta)$

$\Rightarrow \cos\theta = 1 - \dfrac{v_0^2}{2gl}$

$\Rightarrow \theta = \cos^{-1}\left(1 - \dfrac{v_0^2}{2gl}\right)$

Very Similar

Practice Paper *for* AIEEE 2007

Exam on 29th April 2007

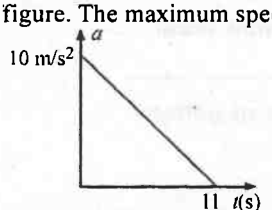
1. Refractive index μ is given as

$$\mu = A + \frac{B}{\lambda^2}$$

where A and B are constants and λ is wavelength, then dimensions of B are same as that of
(a) wavelength (b) volume
(c) pressure (d) area.

2. If $|\vec{A} \times \vec{B}| = \sqrt{3}\,(\vec{A} \cdot \vec{B})$, then the value of $|\vec{A} + \vec{B}|$ is
(a) $(A^2 + B^2 + AB)^{\frac{1}{2}}$ (b) $\left(A^2 + B^2 + \frac{AB}{\sqrt{3}}\right)^{\frac{1}{2}}$
(c) $A + B$ (d) $\left(A^2 + B^2 + \sqrt{3}AB\right)^{\frac{1}{2}}$

3. A particle starts from rest. Its acceleration (a) versus time (t) is as shown in the figure. The maximum speed of the particle will be
(a) 110 m/s
(b) 55 m/s
(c) 550 m/s
(d) 660 m/s



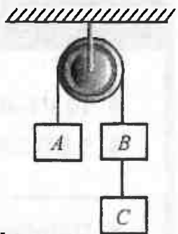
4. A ball is released from the top of tower of height h metre. It takes T second to reach the ground. What is the position of the ball in $T/3$ second?
(a) $\frac{h}{9}$ metre from the ground
(b) $(7h/9)$ metre from the ground
(c) $(8h/9)$ metre from the ground
(d) $(17h/18)$ metre from the ground.

5. The relation between time t and distance x is $t = \alpha x^2 + \beta x$ where α and β are constants. The retardation is
(a) $2\alpha v^3$ (b) $2\beta v^3$
(c) $2\alpha\beta v^3$ (d) $2\beta^2 v^3$

6. A stone is just released from the window of a train moving along a horizontal straight track. The stone will hit the ground following a
(a) straight line path (b) circular path
(c) parabolic path (d) hyperbolic path

7. A car is moving on a circular level road of curvature 300 m. If the coefficient of friction is 0.3 and acceleration due to gravity is 10 m/s², the maximum speed of the car is
(a) 30 km/hr (b) 81 km/hr
(c) 108 km/hr (d) 162 km/hr

8. Three equal weights A, B, C of mass 2 kg each are hanging on a string passing over a fixed frictionless pulley as shown in the figure. The tension in the string connecting weights B and C is



(a) zero (b) 13 N
(c) 3.3 N (d) 19.6 N

9. If μ_k is the coefficient of kinetic friction, μ_r the coefficient of rolling friction and μ_s the coefficient of static friction then generally
(a) $\mu_s > \mu_k > \mu_r$ (b) $\mu_s < \mu_k < \mu_r$
(c) $\mu_s < \mu_k > \mu_r$ (d) $\mu_s > \mu_r > \mu_k$

10. A mass m moving horizontally with velocity v_0 strikes a pendulum of mass m. If the two masses stick together after the collision, then the maximum height reached by the pendulum is
(a) $\frac{v_0^2}{8g}$ (b) $\frac{v_0^2}{2g}$
(c) $\sqrt{2v_0 g}$ (d) $\sqrt{v_0 g}$

11. A ball is dropped from a height 10 m. Ball is embedded in sand 1 m and stops
(a) only momentum remains conserved

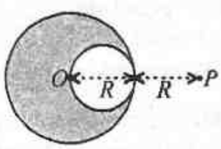
(b) only kinetic energy remains conserved
(c) both momentum and kinetic energy are conserved
(d) neither kinetic energy nor momentum is conserved

12. In a carbon monoxide molecule, the carbon and the oxygen atoms are separated by a distance 1.12×10^{-10} m. The distance of the centre of mass from the carbon atom is
(a) 0.48×10^{-10} m (b) 0.51×10^{-10} m
(c) 0.56×10^{-10} m (d) 0.64×10^{-10} m

13. Two particles of masses m_1 and m_2 are connected by a rigid massless rod of length r to constitute a dumb-bell which is free to move in the plane. The moment of inertia of the dumb-bell about an axis perpendicular to the plane passing through the centre of mass is
(a) $\frac{m_1 m_2 r^2}{m_1 + m_2}$ (b) $(m_1 + m_2)r^2$
(c) $\frac{m_1 m_2 r^2}{m_1 - m_2}$ (d) $(m_1 - m_2)r^2$

14. A satellite of mass m revolves around the earth of radius R at a height x from its surface. If g is the acceleration due to gravity on the surface of the earth, the orbital speed of the satellite is
(a) gx (b) $\frac{gR}{R-x}$
(c) $\frac{gR^2}{R+x}$ (d) $\left(\frac{gR^2}{R+x}\right)^{1/2}$

15. A solid sphere of uniform density and radius R applies a gravitational force of attraction equal to F_1 on a particle placed at P, distance $2R$ from the centre O of the sphere. A spherical cavity of radius $R/2$ is now made in the sphere as shown in figure. The sphere with cavity now applies a gravitational force F_2 on same particle placed at P. The ratio F_2/F_1 will be



(a) 1/2 (b) 7/9
(c) 3 (d) 7

16. For a given material, the Young's modulus is 2.4 times that of modulus of rigidity. Its Poisson's ratio is
(a) 2.4 (b) 1.2
(c) 0.4 (d) 0.2

17. A spring of spring constant 5×10^3 N/m is stretched initially by 5 cm from the unstretched position. The work required to stretch it further by another 5 cm is
(a) 6.25 N-m (b) 12.50 N-m
(c) 18.75 N-m (d) 25.00 N-m

18. Viscosity of liquids
(a) increases with increase in temperature
(b) is independent of temperature
(c) decreases with decrease in temperature
(d) decreases with increase in temperature

19. A U-tube is partially filled with water. Oil which does not mix with water is next poured into one side, until water rises by 25 cm on the other side. If the density of oil is 0.8 g/cm³, the oil level will stand higher than the water level by
(a) 6.25 cm (b) 12.50 cm
(c) 31.75 cm (d) 62.50 cm

20. Two thermally insulated vessels 1 and 2 are filled with air at temperatures (T_1, T_2), volume (V_1, V_2) and pressure (P_1, P_2) respectively. If the valve joining the two vessels is opened, the temperature inside the vessel at equilibrium will be
(a) $T_1 + T_2$ (b) $(T_1 + T_2)/2$
(c) $\frac{T_1 T_2 P(V_1 + V_2)}{P_1 V_1 T_2 + P_2 V_2 T_1}$ (d) $\frac{T_1 T_2 (P_1 V_1 + P_2 V_2)}{P_1 V_1 T_1 + P_2 V_2 T_2}$

21. Two marks on a glass rod 10 cm apart are found to increase their distance by 0.08 mm when the rod is heated from 0°C to 100°C. A flask made of the same glass as that of rod measures a volume of 1000 cc at 0°C. The volume it measures at 100°C in cc is
(a) 1002.4 (b) 1004.2
(c) 1006.4 (d) 1008.2

22. A kettle with 2 litre water at 27°C is heated by operating coil heater of power 1 kW. The heat is lost to the atmosphere at constant rate 160 J/sec, when its lid is open. In how much time will water heated to 77°C with the lid open? (specific heat of water = 4.2 kJ/kg)
(a) 8 min 20 sec (b) 6 min 2 sec
(c) 14 min (d) 7 min

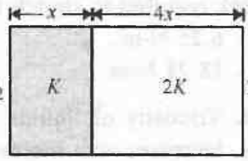
23. The temperature of the two outer surfaces of a composite slab consisting of two materials having coefficients of thermal conductivity K and $2K$ and thickness x and $4x$ respectively are T_2 and $T_1 (T_2 > T_1)$. The rate of heat transfer through the slab, in a steady state is $\left(\frac{A(T_2 - T_1)K}{x}\right)f$ with f equal to

(a) 1

(b) 1/2

(c) 2/3

(d) 1/3



24. Two cylinders fitted with pistons contain equal amount of an ideal diatomic gas at 300 K. The piston of A is free to move, while that of B is held fixed. The same amount of heat is given to the gas in each cylinder. If the rise in temperature of the gas in A is 30 K, then the rise in temperature of gas in B is

(a) 30 K (b) 18 K

(c) 50 K (d) 42 K

25. The displacement of a particle varies according to the relation $x = 4(\cos\pi t + \sin\pi t)$. The amplitude of the particle is where x in m and t is second

(a) 8 m (b) 2 m

(c) 4 m (d) $4\sqrt{2}$ m

26. A mass M is suspended from a spring of negligible mass. The spring is pulled a little and then released, so that the mass executes simple harmonic motion of time period T. If the mass is increased by m, the time period becomes $\frac{5T}{3}$. The ratio of m/M is

(a) $\frac{5}{3}$ (b) $\frac{3}{5}$

(c) $\frac{16}{9}$ (d) $\frac{25}{9}$

27. Oxygen is 16 times heavier than hydrogen. The equal volumes of hydrogen and oxygen are mixed. The ratio of speed of sound in the mixture to that in hydrogen is

(a) $\sqrt{8}$ (b) $\sqrt{\frac{1}{8}}$

(c) $\sqrt{\frac{2}{17}}$ (d) $\sqrt{\frac{32}{17}}$

28. Equation of a progressive wave is given by,

$$y = 4\sin\left[\pi\left(\frac{t}{5} - \frac{x}{9}\right) + \frac{\pi}{6}\right]$$

where x, y are in metre and t is in second. Then which of the following is correct?

(a) $v = 5$ m/s (b) $\lambda = 18$ m

(c) $a = 0.04$ m (d) $f = 50$ Hz

29. An organ pipe open at one end is vibrating in first overtone and is in resonance with another pipe open at both ends and vibrating in third harmonic. The ratio of length of two pipes is

(a) 1 : 2 (b) 4 : 1

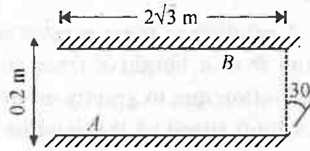
(c) 8 : 3 (d) 3 : 8

30. One train is approaching an observer at rest and another train is receding from him with the same velocity 4 m/s. Both trains blow whistles of same frequency of 243 Hz. The beat frequency in Hz as heard by the observer is (speed of sound in air = 320 m/s)

(a) 10 (b) 6

(c) 4 (d) 1

31. Two plane mirror A and B are aligned parallel to each other, as shown in the figure. A light ray is incident at an angle of 30° at a point just inside one end of A. The plane of incidence coincides with the plane of figure. The maximum number of times the ray undergoes reflections (including the first one) before it emerges out is



(a) 28

(b) 30

(c) 32

(d) 34

32. An endoscope is employed by a physician to view the internal parts of body organ. It is based on the principle of

(a) refraction (b) reflection

(c) total internal reflection

(d) dispersion

33. A point object is placed at a distance of 10 cm and its real image is formed at a distance of 20 cm from a concave mirror. If the object is moved by 0.1 cm towards the mirror, the image will shift by about

(a) 0.4 cm away from the mirror

(b) 0.4 cm towards the mirror

(c) 0.8 cm away from the mirror

(d) 0.8 cm towards the mirror

34. A telescope, whose objective lens has an aperture of 1 mm for the wavelength of light 500 Å, then limiting resolving power of the telescope is

(a) 2.1×10^{-5} rad (b) 4.1×10^{-5} rad

(c) 5.1×10^{-5} rad (d) 6.1×10^{-5} rad

35. If light is polarised by reflection, then the angle between reflected and refracted light is

(a) π (b) $\frac{\pi}{2}$

(c) 2π (d) $\frac{\pi}{4}$

36. In Young's double slit experiment, distance between two sources is 0.1 mm. The distance of screen from the sources is 20 cm. Wavelength of light used is 5460Å. Then angular position of first dark fringe is

(a) 0.08° (b) 0.16°

(c) 0.20° (d) 0.32°

37. Two thin wire rings each having radius R are placed at a distance d apart with their axes coinciding. The charges on the two rings are $+Q$ and $-Q$. The potential difference between the centres of the two rings is

(a) zero (b) $\frac{Q}{4\pi\varepsilon_0}\left[\frac{1}{R}-\frac{1}{\sqrt{R^2+d^2}}\right]$

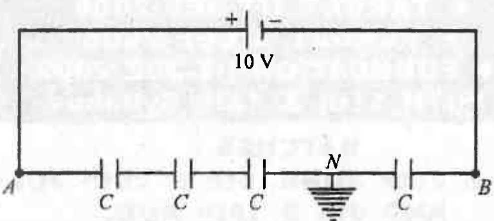
(c) $\frac{Q}{4\pi\varepsilon_0 d^2}$ (d) $\frac{Q}{2\pi\varepsilon_0}\left[\frac{1}{R}-\frac{1}{\sqrt{R^2+d^2}}\right]$

38. The electric field at a distance 2 cm from the centre of a hollow spherical conducting shell of radius 4 cm having a charge of 2×10^{-3} C on its surface is

(a) 1.1×10^{10} V/m (b) 4.5×10^{-10} V/m

(c) 4.5×10^{10} V/m (d) zero

39. Four identical capacitors are connected in series with a 10 V battery as shown in the figure. The point N is earthed. The potentials of points A and B are



(a) 10 V, 0 V (b) 7.5 V, –2.5 V

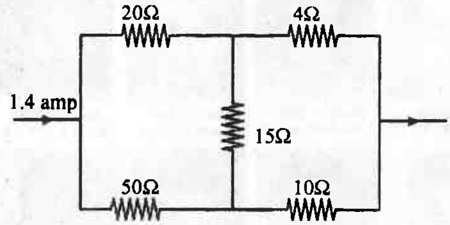
(c) 5 V, –5 V (d) 7.5 V, 2.5 V

40. Potentiometer wire of length 1 m is connected in series with 490 Ω resistance and 2V battery. If 0.2 mV/cm is the potential gradient, then resistance of the potentiometer wire is

(a) 4.9 Ω (b) 7.9 Ω

(c) 5.9 Ω (d) 6.9 Ω

41. In the following figure the current through 4 ohm resistor is :



(a) 1.4 amp (b) 0.4 amp

(c) 1.0 amp (d) 0.7 amp

42. The electrochemical equivalent of metal is 3.3×10^{-7} kg per coulomb. The mass of the metal liberated at the cathode when a 3 A current is passed for 2 second will be

(a) 19.8×10^{-7} kg (b) 9.9×10^{-7} kg

(c) 6.6×10^{-7} kg (d) 1.1×10^{-7} kg

43. A current of 5 ampere is passed through a straight wire of length 6 cm, then the magnetic induction at a point 5 cm from the either end of the wire is

(a) 0.25 gauss (b) 0.125 gauss

(c) 0.15 gauss (d) 0.30 gauss

44. The magnetic field due to a current carrying circular loop of radius 3 m at a point on the axis at a distance of 4 m from the centre is 54 μT. What will be its value at the centre of the loop?

(a) 250 μT (b) 150 μT

(c) 125 μT (d) 75 μT

45. A galvanometer has a resistance of 3663 ohm. A shunt S is connected across it such that (1/34) of the total current passes through the galvanometer. Then the value of the shunt is

(a) 3663 ohm (b) 111 ohm

(c) 107.7 ohm (d) 3555.3 ohm

46. The armature of a DC motor has 20 Ω resistance. It draws a current of 1.5 amp when run by 220 volt DC supply. The value of back emf induced in it will be

(a) 150 V (b) 170 V

(c) 180 V (d) 190 V

47. In a transformer the output current and voltage are respectively 4 A and 20 V. If the ratio of number of turns in the primary to secondary is 2 : 1, what is the input current and voltage?

(a) 2 A and 40 V (b) 1 A and 20 V

(c) 4 A and 10 V (d) 8 A and 40 V

48. In Millikan's oil drop experiment an oil drop of radius r and charge q is held in equilibrium between the plates of a charged parallel plate capacitor when the potential difference is V. To keep a drop of radius $2r$ and with a charge $2q$ in equilibrium between the plates the potential difference V' required is

(a) V (b) $2V$
(c) $4V$ (d) $8V$

49. Two identical photocathodes receive light of frequencies υ_1 and υ_2. If the velocities of the photoelectrons (of mass m) coming out are v_1 and v_2 respectively, then

(a) $v_1 - v_2 = \left[\frac{2h}{m}(\upsilon_1 - \upsilon_2)\right]^{1/2}$

(b) $v_1^2 - v_2^2 = \frac{2h}{m}(\upsilon_1 - \upsilon_2)$

(c) $v_1 + v_2 = \left[\frac{2h}{m}(\upsilon_1 - \upsilon_2)\right]^{1/2}$

(d) $v_1^2 + v_2^2 = \frac{2h}{m}(\upsilon_1 - \upsilon_2)$

50. According to Einstein's photoelectric equation, the plot of the kinetic energy of the emitted photoelectrons from a metal versus frequency of the incident radiation gives a straight line whose slope

(a) depends on the nature of metal used
(b) depends on the intensity of radiation
(c) depends on both intensity of radiation and the nature of metal used
(d) is the same for all metals and independent of the intensity of radiation.

51. The energy of a hydrogen like atom (or ion) in its ground state is –122.4 eV. It may be

(a) hydrogen atom (b) He^+
(c) Li^{2+} (d) Be^{3+}

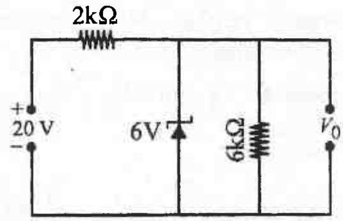
52. Starting with a sample of pure ^{66}Cu, (7/8) of it decays into Zn in15 minutes. The corresponding half-life is

(a) 5 minutes (b) $7\frac{1}{2}$ minutes
(c) 10 minutes (d) 14 minutes

53. On bombardment of U^{235} by slow neutrons, 200 MeV energy is released. If the power output of atomic reactor is 1.6 MeV, then the rate of fission will be

(a) 5×10^{16} per second (b) 10×10^{16} per second
(c) 15×10^{16} per second (d) 20×10^{16} per second

54. What is the value of output voltage V_0 in the circuit as shown in the figure?



(a) 42 V (b) 14 V
(c) 7 V (d) 6 V

55. Figure (a) shows a logic gate circuit with two inputs A and B and the output C. The voltage wave forms of A, B and C are shown in figure (b). The logic circuit is

(a) OR gate (b) AND gate
(c) NAND gate (d) NOR gate

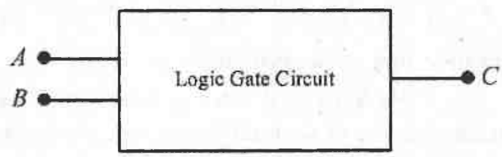


Figure (a)

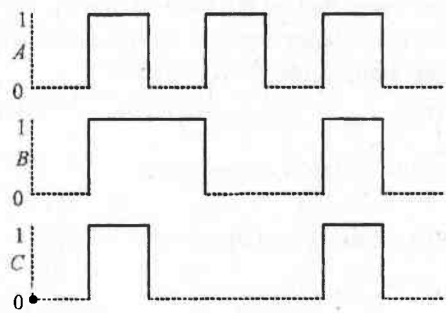


Figure (b)

SOLUTION

1. (d): As $\mu = \frac{\text{velocity of light in vacuum}}{\text{velocity of light in medium}}$, hence μ is dimensionless. Thus each term on the RHS of given equation should be dimensionless.

$\therefore B/\lambda^2$ is dimensionless. *i.e.* B should have dimensions of λ^2, *i.e.*, m^2, *i.e.*, area.

2. (a) : Given $|\vec{A} \times \vec{B}| = \sqrt{3}\,(\vec{A} \cdot \vec{B})$

Hence, $AB\sin\theta = \sqrt{3}AB\cos\theta$

or $\tan\theta = \sqrt{3}$ or $\theta = 60°$

$|\vec{A} + \vec{B}| = (A^2 + B^2 + 2AB\cos 60°)^{1/2}$

$$= \left(A^2 + B^2 + 2AB \times \frac{1}{2}\right)^{1/2} = (A^2 + B^2 + AB)^{1/2}$$

3. **(b)** : The area under the acceleration-time graph gives change in velocity. Since particle starts with $u = 0$, therefore change in velocity $= v_f - v_i = v_{max} - 0$ = area under a - t graph $= \frac{1}{2} \times 10 \times 11 = 55$ m/s.

4. **(c)** : $h = \frac{1}{2} gT^2$

In $\frac{T}{3}$ sec, the distance travelled $= \frac{1}{2} g \left(\frac{T}{3}\right)^2 = \frac{h}{9}$

$\therefore$ Position of the ball from the ground

$$= h - \frac{h}{9} = \frac{8h}{9} \text{ m}$$

5. **(a)** : $t = \alpha x^2 + \beta x = x(\alpha x + \beta)$

Differentiate w.r.t to time on both sides, we get

$1 = 2\alpha \frac{dx}{dt} \cdot x + \beta \frac{dx}{dt}$

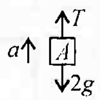
$\therefore v = \frac{dx}{dt} = \frac{1}{\beta + 2\alpha x}; \frac{dv}{dt} = \frac{-2\alpha v}{(\beta + 2\alpha x)^2} = -2\alpha v^3$

Negative sign show retardation.

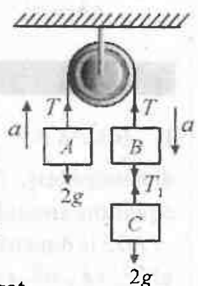
6. **(c)** : The horizontal velocity of the stone will be the same as that of the train. In this way, the horizontal motion will be uniform motion. The vertical motion will be controlled by the force of gravity, *i.e.* vertical motion is accelerated motion. Thus the resultant motion will be along a parabolic trajectory.

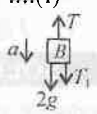
7. **(c)** : $v_{max} = \sqrt{\mu rg} = \sqrt{0.3 \times 300 \times 10} = 30$ m/s

$= 30 \times \frac{18}{5}$ km/hr $= 108$ km/hr

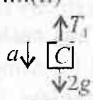
8. **(b)** : Free body diagram of A 

For A : $T - 2g = 2a$ ....(i)



Free body diagram of B 

For B : $T_1 + 2g - T = 2a$ ....(ii)

Free body diagram of C 

For C : $2g - T_1 = 2a$ ....(iii)

Adding equation (i) and (ii), we get

$T_1 = 4a$ ....(iv)

From equation (iii) and (iv), we get

$2g - 4a = 2a$ or $a = g/3$ ....(v)

From equations (iv) and (v), we get

$T_1 = 4 \times \frac{g}{3} = 13$ N

9. **(a)** : $\mu_s > \mu_k > \mu_r$. Rolling friction is always less than sliding friction, that is why it is easy to move a heavy load from one place to another by rolling it over the surface instead of sliding it over the same surface. Moreover, it is quite obvious that static friction is always greater than kinetic friction.

10. **(a)** : Applying the law of conservation of momentum, we get

$mv_0 + m \times 0 = 2m \times v$ or $v = \frac{v_0}{2}$

Kinetic energy $= \frac{1}{2}(2m)v^2 = \frac{1}{2} \times 2m \times \left(\frac{v_0}{2}\right)^2 = \frac{mv_0^2}{4}$

Let the system reach a height h.

Potential energy of the system $= 2mgh$

Hence, $\frac{mv_0^2}{4} = 2mgh$ or $h = \frac{v_0^2}{8g}$

11. **(a)** : It is an example of inelastic collision. In inelastic collision momentum is conserved but kinetic energy is not conserved.

12. **(d)** : $R_{CM} = \frac{12 \times 0 + 16 \times 1.12 \times 10^{-10}}{12 + 16}$

$= \frac{16}{28} \times 1.12 \times 10^{-10}$ m $= 0.64 \times 10^{-10}$ m

13. **(a)** : Suppose C be the centre of mass of the dumb-bell. Let the particles of masses m_1 and m_2 be placed at distances r_1 and r_2 from C. Hence, moment of inertia of given system about an axis passing through centre of mass

$I = m_1 r_1^2 + m_2 r_2^2$ ...(i)

According to definition of centre of mass,

$m_1 r_1 = m_2 r_2$ ...(ii)

Also, $r_1 + r_2 = r$ ...(iii)

Solving for r_1 and r_2 from (ii) and (iii), we get

$r_1 = \frac{m_2 r}{m_1 + m_2}$ ...(iv)

and $r_2 = \frac{m_1 r}{m_1 + m_2}$ ...(v)

Putting (iv) and (v) in equation (i), we get

$I = \frac{m_1 m_2 r^2}{m_1 + m_2} = \mu r^2$

where $\mu = \frac{m_1 m_2}{m_1 + m_2}$ is called as reduced mass of the system.

14. **(d)** : For the satellite, the gravitational force provides the necessary centripetal force, *i.e.*,

$\frac{GM_e m}{(R + x)^2} = \frac{mv_0^2}{(R + x)}$ and $\frac{GM_e}{R^2} = g$ $\therefore v_0 = \sqrt{\frac{gR^2}{R + x}}$

15. (b) : Gravitational force due to solid sphere, $F_1 = \frac{GMm}{4R^2}$, where M and m are mass of the solid sphere and particle respectively and R is the radius of the sphere. The gravitational force on particle due to sphere with cavity = force due to solid sphere – force due to sphere creating cavity, assumed to be present above at that position.

i.e., $F_2 = \frac{GMm}{4R^2} - \frac{G(M/8)m}{(3R/2)^2} = \frac{7}{36}\frac{GMm}{R^2}$

So $\frac{F_2}{F_1} = \frac{7GMm/36R^2}{GMm/4R^2} = \frac{7}{9}$.

16. (d) : $Y = 2\eta\,(1 + \sigma)$

where Y = Young's modulus, η = modulus of rigidity, σ = Poisson's ratio

Given : $Y = 2.4\eta$

$\therefore$ $2.4\eta = 2\eta(1 + \sigma)$ or $1 + \sigma = 1.2$ or $\sigma = 0.2$

17. (c) : $k = 5 \times 10^3$ N/m, $y_1 = 5 \times 10^{-2}$ m

$y_2 = y_1 + 5 = 10$ cm $= 10 \times 10^{-2}$ m

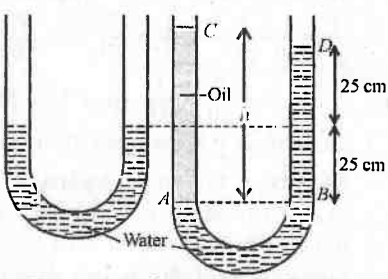
$W_1 = \frac{1}{2}ky_1^2 = \frac{1}{2} \times (5 \times 10^3) \times (5 \times 10^{-2})^2 = 6.25$ N-m

$W_2 = \frac{1}{2}ky_2^2, \quad \frac{W_2}{W_1} = (y_2/y_1)^2 = 4$

$W_2 = 4W_1 = 25.0$ N-m $\therefore \Delta W = W_2 - W_1 = 18.75$ N-m

18. (d)

19. (b) : On pouring oil on left side, water rises by 25 cm from its previous level in the right limb of U-tube, creating a difference of levels of water by 50 cm. Let h cm be the height of oil above level A in the left limb of U-tube.



Equating pressures at A and B, we get $P_A = P_B$

$h \times \rho_{oil} \times g = 50 \times \rho_{water} \times g$

$\therefore h = \frac{50 \times \rho_{water}}{\rho_{oil}} = \frac{50 \times 1}{0.8} = 62.5$ cm

$\therefore$Difference of levels of oil (C) and water (D) in the two limbs = 62.5 – 50 = 12.5 cm.

20. (c) : The number of moles of system remains same

$\frac{P_1V_1}{RT_1} + \frac{P_2V_2}{RT_2} = \frac{P(V_1 + V_2)}{RT}$ or $T = \frac{P(V_1 + V_2)T_1T_2}{(P_1V_1T_2 + P_2V_2T_1)}$

21. (a) : $\gamma = \frac{V_2 - V_1}{V_1(T_2 - T_1)}$; $\alpha = \frac{l_2 - l_1}{l_1(T_2 - T_1)}$

$T_1 = 0°C, T_2 = 100°C$

$\gamma = \frac{V_2 - V_1}{100\,V_1}, \alpha = \frac{l_2 - l_1}{100\,l_1}$

$l_1 = 10$ cm; $l_2 - l_1 = 0.08$ mm $= 0.008$ cm

$\alpha = \frac{0.008}{10 \times 100} = 8 \times 10^{-6}/°C$; $\gamma = 3\alpha = 24 \times 10^{-6}/°C$

$\therefore\ 24 \times 10^{-6} = \frac{V_2 - 1000}{1000 \times 100}$

$V_2 - 1000 = 24 \times 10^{-6} \times 10^5 = 2.4$ $\therefore V_2 = 1002.4$ cc

22. (a) : By the law of conservation of energy, energy given by heater must be equal to the sum of energy gained by water and energy lost from the lid.

$Pt = ms\Delta\theta$ + energy lost

$1000t = 2 \times 4.2 \times 10^3 \times 50 + 160t$

$840t = 8.4 \times 10^3 \times 50 = 500$ sec $= 8$ min 20 sec

23. (d) : For slab in series, we have

$R_{eq} = R_1 + R_2 = \frac{x}{KA} + \frac{4x}{2KA} = \frac{3x}{KA}$

Now, in a steady state rate of heat transfer through the slab is given by

$\frac{dQ}{dt} = \frac{T_2 - T_1}{R_{eq}} = \frac{(T_2 - T_1)}{3x}KA$ ... (i)

Given $\frac{dQ}{dt} = \left(\frac{A(T_2 - T_1)K}{x}\right)f$ ...(ii)

Comparing (i) and (ii), we get $f = 1/3$.

24. (d) : In cylinder A, heat is supplied at constant pressure while in cylinder B heat is supplied at constant volume.

$(\Delta Q)_A = nC_P(\Delta T)_A$ and $(\Delta Q)_B = nC_V(\Delta T)_B$

Given : $(\Delta Q)_A = (\Delta Q)_B$

$\therefore (\Delta T)_B = \frac{C_P}{C_V}(\Delta T)_A = 1.4 \times 30 = 42$ K

[$\because$ For diatomic gas $\frac{C_P}{C_V} = 1.4$]

25. (d) : $x = 4(\cos \pi t + \sin \pi t)$

$= 4\sqrt{2}\left[\frac{1}{\sqrt{2}}\cos \pi t + \frac{1}{\sqrt{2}}\sin \pi t\right]$

$= 4\sqrt{2}\left[\sin\frac{\pi}{4}\cos \pi t + \cos\frac{\pi}{4}\sin \pi t\right]$

$= 4\sqrt{2}\sin\left(\pi t + \frac{\pi}{4}\right)$

Standard equation of displacement is

$x = a\sin(\omega t + \phi)$

Comparing the given equation with standard equation

$a = 4\sqrt{2}$ m

26. (c) : $m_1 = M,\ T_1 = T$

$$m_2 = M + m,\ T_2 = \frac{5T}{3}$$

$$\frac{T_1}{T_2} = \frac{2\pi\sqrt{m_1/k}}{2\pi\sqrt{m_2/k}} = \sqrt{\frac{m_1}{m_2}} = \sqrt{\frac{M}{M+m}}$$

or $\dfrac{M+m}{M} = \left(\dfrac{T_2}{T_1}\right)^2 = \left(\dfrac{5T/3}{T}\right)^2 = \dfrac{25}{9}\quad \therefore \dfrac{m}{M} = \dfrac{16}{9}$

27. (c): Given : Molecular mass of oxygen (M_O) = $16M_H$. (where M_H is the molecular mass of hydrogen) and volume of oxygen $V_O = V_H$ (where V_H is the volume of hydrogen).

Molecular mass of mixture is

$M_{mix} = M_O + M_H = 16\ M_H + M_H = 17M_H$

and volume of the mixture is

$(V_{mix}) = V_O + V_H = V_H + V_H = 2V_H$.

Density of a gas, $\rho = \dfrac{M}{V}$

Therefore, $\dfrac{\rho_{mix}}{\rho_H} = \dfrac{M_{mix}}{M_H} \times \dfrac{V_H}{V_{mix}} = \dfrac{17M_H}{2M_H} = \dfrac{17}{2}$

Velocity of sound in a gas is given by

$v = \sqrt{\dfrac{\gamma P}{\rho}}$. *i.e.* $v \propto \dfrac{1}{\sqrt{\rho}}$

Therefore, $\dfrac{v_{mix}}{v_H} = \sqrt{\dfrac{\rho_H}{\rho_{mix}}} = \sqrt{\dfrac{2}{17}}$

28. (b) : Given : $y = 4\sin\left[\pi\left(\dfrac{t}{5} - \dfrac{x}{9}\right) + \dfrac{\pi}{6}\right]$ .... (i)

Standard equation : $y = a\sin\left[2\pi\left(\upsilon t - \dfrac{x}{\lambda}\right) + \phi\right]$...(ii)

Comparing (i) and (ii), we get

$$2\pi\upsilon = \frac{\pi}{5} \text{ or } \upsilon = \frac{1}{10}\text{ Hz}$$

$$\frac{2\pi}{\lambda} = \frac{\pi}{9} \text{ or } \lambda = 18\text{ m}$$

Velocity $v = \upsilon\lambda = \dfrac{1}{10} \times 18 = 1.8$ m/s

Amplitude $a = 4$ m.

29. (a) : In the first overtone of organ pipe open at one end

$$\upsilon_C = \frac{3v}{4l_C} \quad ...(i)$$

Third harmonic or second overtone of organ pipe open at both end.

$$\upsilon_O = \frac{3v}{2l_O} \quad ...(ii)$$

From equations (i) and (ii), we get

Given : $\upsilon_C = \upsilon_O$ or $\dfrac{3v}{4l_C} = \dfrac{3v}{2l_O}$ or $\left(\dfrac{l_C}{l_O}\right) = \dfrac{1}{2}$

30. (b) : When the train is approaching,

$$\upsilon_1 = \frac{v}{v - v_s} \times \upsilon = \frac{320}{320-4} \times 243 = \frac{80}{79} \times 243$$

$$\upsilon_1 = \frac{80}{79} \times 243$$

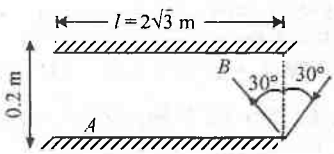
When the train is receding

$$\upsilon_2 = \frac{v}{v + v_s} \times \upsilon = \frac{320}{324} \times 243 = \frac{80}{81} \times 243$$

Beat frequency is

$$\upsilon_1 - \upsilon_2 = 80 \times 243\left(\frac{1}{79} - \frac{1}{81}\right) = 6\text{ Hz}$$

31. (b) : As is clear from the figure



$d = 0.2\tan 30° = \dfrac{0.2}{\sqrt{3}}$; $\dfrac{l}{d} = \dfrac{2\sqrt{3}}{0.2/\sqrt{3}} = 30$

$\therefore$ Max number of reflections = 30.

32. (c)

33. (a) : From mirror equation,

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} = -\frac{1}{20} - \frac{1}{10} = -\frac{3}{20}$$

$\therefore\ \dfrac{1}{v'} = -\dfrac{3}{20} + \dfrac{1}{9.9}$ or $v' = -20.4$ cm

i.e. shift is 0.4 cm away from the mirror.

34. (d) : Given : Aperture of objective lens (a) = 1 mm = 1×10^{-3} m and wavelength of light (λ) = 500Å = 500×10^{-10} m.

Limiting resolving power of telescope,

$$d\theta = \frac{1.22\lambda}{a} = \frac{1.22 \times 500 \times 10^{-10}}{1 \times 10^{-3}} = 6.1 \times 10^{-5}\text{ rad}$$

35. (b)

36. (b) : $d = 0.1$ mm $= 10^{-4}$ m, $D = 20$ cm $= \dfrac{1}{5}$ m

$\lambda = 5460$ Å $= 5.46 \times 10^{-7}$ m

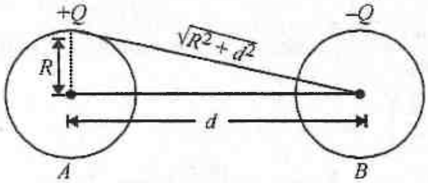
Angular position of first dark fringe is

$$\theta = \frac{\lambda}{2d} = \frac{5.46 \times 10^{-7}}{2 \times 10^{-4}} = 2.73 \times 10^{-3}\text{ radian}$$

$$= 2.73 \times 10^{-3} \times \frac{180°}{\pi} = 0.156°$$

37. (d) : Potential of ring A

$$V_A = \frac{KQ}{R} - \frac{KQ}{\sqrt{R^2+d^2}} \qquad \left(K = \frac{1}{4\pi\varepsilon_0}\right)$$



Potential of ring B

$$V_B = \frac{-KQ}{R} + \frac{KQ}{\sqrt{R^2+d^2}}$$

$$\therefore\ V_A - V_B = \frac{Q}{2\pi\varepsilon_0}\left[\frac{1}{R} - \frac{1}{\sqrt{R^2+d^2}}\right]$$

38. (d) : Electric field inside the hollow conducting sphere is zero.

39. (b) : If q is the charge on each capacitor, then

$$\frac{q}{C}+\frac{q}{C}+\frac{q}{C}+\frac{q}{C} = 10 \text{ or } \frac{q}{C} = 2.5 \text{ V}$$

$$V_A - V_N = \frac{q}{C}+\frac{q}{C}+\frac{q}{C}$$

or $V_A - 0 = 2.5 + 2.5 + 2.5 = 7.5$ V

Also, $\frac{q}{C} = V_N - V_B = 0 - V_B$

or $2.5 = 0 - V_B$ or $V_B = -2.5$ V

40. (a) : Potential across potentiometer wire

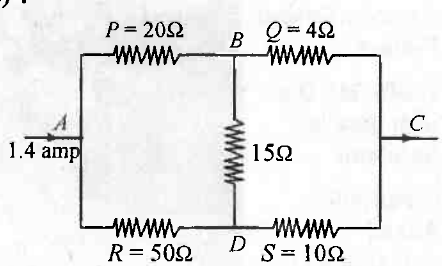
$$= \frac{(0.2\times10^{-3})\text{ V}\times 1\text{ m}}{10^{-2}\text{ m}} = 0.02 \text{ V}$$

Also $0.02 = \frac{R}{r+R}\times 2$

where R is resistance of potentiometer wire and r is resistance connected in series.

$0.02(490 + R) = 2R$ Solving $R = 4.9\ \Omega$

41. (c) :



Here $\frac{P}{Q} = \frac{R}{S}$

$$\frac{20}{4} = \frac{50}{10} \Rightarrow 5 = 5$$

i.e. the bridge is balanced; hence current through 15 Ω resistor is zero. Hence, 15 Ω resistor is ineffective.

$\therefore\ R_{ABC} = 20 + 4 = 24\ \Omega$

$R_{ADC} = 50 + 10 = 60\ \Omega$

$$R_{AC} = \frac{R_{ABC}R_{ADC}}{R_{ABC}+R_{ADC}} = \frac{24\times60}{24+60} = \frac{120}{7}\ \Omega$$

So, $V_A - V_C = 1.4 \times \frac{120}{7} = 24$ volt

So current through ABC, $I_1 = \frac{V_A - V_C}{R_{ABC}} = \frac{24}{24} = 1$ amp

Current through ADC, $I_2 = \frac{V_A - V_C}{R_{ADC}} = \frac{24}{60} = 0.4$ amp

So current through 4 Ω resistor, $I_1 = 1$ ampere

No current will flow through 15 Ω resistor.

42. (a) : According to Faraday's first law of electrolysis, $m = ZIt$ $\therefore$ $m = 3.3\times10^{-7}\times3\times2 = 19.8\times10^{-7}$ kg

43. (c) : Let AB represents the current carrying conductor and P be the point where magnetic induction B is required.

Now $B = \frac{\mu_0 I}{4\pi r}[\sin\phi_1 + \sin\phi_2]$

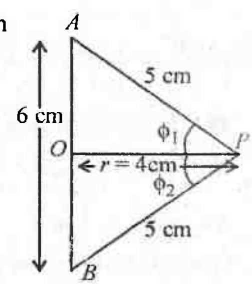
Here $r = OP$

Now $AO = OB = \frac{6}{2}$ cm $= 3$ cm

and $PB = PA = 5$ cm

$\therefore OP = \sqrt{(5)^2-(3)^2} = 4$ cm

$\therefore\ r = 4$ cm $= 4\times10^{-2}$ metre



$\sin\phi_1 = \frac{3}{5}$ and $\sin\phi_2 = \frac{3}{5}$

$$B = 10^{-7}\times\left(\frac{5}{4\times10^{-2}}\right)\left[\frac{3}{5}+\frac{3}{5}\right]$$

$$= \frac{6}{4}\times10^{-5} = 0.15\times10^{-4} \text{ tesla} = 0.15 \text{ gauss.}$$

44. (a) : $B = \frac{\mu_0 iR^2}{2(R^2+x^2)^{3/2}}$ or $54 = \frac{\mu_0 i(3)^2}{2[3^2+4^2]^{\frac{3}{2}}}$

or $\mu_0 i = \frac{54\times2\times5\times25}{9}$

Now, at the centre of the coil, $x = 0$ and

$$B = \frac{\mu_0 i}{2R} = \frac{\mu_0 i}{2\times3} = \frac{\mu_0 i}{6} = \frac{54\times2\times5\times25}{9\times6} = 250\ \mu\text{T}$$

45. (b): $\frac{I_g}{I} = \frac{S}{S+G}$ or $\frac{1}{34} = \frac{S}{S+G}$

$S = (G/33) = (3663/33) = 111\ \Omega$

46. (d) : $I = \dfrac{E - \varepsilon}{R}$ where ε is the induced back emf

or $1.5 = \dfrac{E - \varepsilon}{R}$ or $1.5 = \dfrac{220 - \varepsilon}{20}$ or $\varepsilon = 190$ V

47. (a) : Given : $\dfrac{N_p}{N_s} = \dfrac{2}{1}$

$\dfrac{V_s}{V_p} = \dfrac{N_s}{N_p}$ or $\dfrac{V_s}{V_p} = \dfrac{1}{2}$ ∴ $V_p = 2V_s = 2 \times 20 = 40$ V

Since the input power = output power (for ideal transformer)

$\therefore I_p V_p = I_s V_s \quad \therefore I_p = \dfrac{I_s V_s}{V_p} = \dfrac{4 \times 20}{40} = 2$ amp

48. (c) : In Millikan's oil drop experiment,
For drop to be remain stationary

$qE = Mg$ Here $E = \dfrac{V}{d}$ and $M = \dfrac{4}{3}\pi r^3 \rho$

$\therefore \dfrac{qV}{d} = \dfrac{4}{3}\pi r^3 \rho g$

or $V = \left(\dfrac{d}{q}\right)\dfrac{4}{3}\pi r^3 \rho g = \left(\dfrac{r^3}{q}\right)\left(\dfrac{4}{3}\pi\rho d\right) g$

For second oil drop, $V' = \left[\dfrac{(2r)^3}{2q}\right]\left[\dfrac{4}{3}\pi\rho d\right] g$

$\therefore \dfrac{V'}{V} = 4$ or $V' = 4V$

49. (b) : According to Einstein's photoelectric equation

$h\upsilon_1 = h\upsilon_0 + \dfrac{1}{2}mv_1^2$ ...(i)

$h\upsilon_2 = h\upsilon_0 + \dfrac{1}{2}mv_2^2$ ...(ii)

From (i) and (ii), we get

$\therefore h(\upsilon_1 - \upsilon_2) = \dfrac{1}{2}m(v_1^2 - v_2^2)$

$\therefore v_1^2 - v_2^2 = \dfrac{2h}{m}(\upsilon_1 - \upsilon_2)$

50. (d) : According to Einstein's photoelectric equation
$(KE)_{max.} = h\upsilon - W$
The slope of the line in the graph is h, the Planck's constant.

51. (c) : $E_n^Z = -\dfrac{13.6 \times Z^2}{n^2}$ eV

For ground state, $n = 1 \quad \therefore E_1^Z = -13.6 \times Z^2$ eV

Here $E_1^Z = -122.4$ eV ∴ $-122.4 = -13.6 \times Z^2$ or $Z = 3$

52. (a) : Sample remain undecayed is $N = \dfrac{1}{8}N_0$

$\therefore \dfrac{N}{N_0} = \left(\dfrac{1}{2}\right)^n$ when n is the number of half lives

$\dfrac{1}{8} = \left(\dfrac{1}{2}\right)^n$ or $n = 3$

$\therefore n = 3 = \dfrac{t}{T_{\frac{1}{2}}}$ or $T_{\frac{1}{2}} = \dfrac{15}{3} = 5$ min

53. (a) : The rate of fission $= \dfrac{1.6 \text{ MeV}}{200 \times 1.6 \times 10^{-19} \text{ MeV}}$
$= 5 \times 10^{16}$ per second.

54. (d) : In the circuit zener diode is used as voltage regulating device. The output voltage $V_0 = 6$ V, which is the potential across the zener diode because in parallel, the potetial remains the same.

55. (b) : The Boolean expression which satisfies the output of this logic gate is $C = A \cdot B$, which is for AND gate. ■

Model Test Paper
CBSE-PMT 2008

Full Length

PHYSICS

1. If $\vec{A} = 2\hat{i} + 4\hat{j} - 5\hat{k}$ the direction cosines of the vector $\vec{A}$ are
   (a) $\frac{2}{\sqrt{45}}, \frac{4}{\sqrt{45}}$ and $\frac{-5}{\sqrt{45}}$
   (b) $\frac{1}{\sqrt{45}}, \frac{2}{\sqrt{45}}$ and $\frac{3}{\sqrt{45}}$
   (c) $\frac{4}{\sqrt{45}}$, 0 and $\frac{4}{\sqrt{45}}$
   (d) $\frac{3}{\sqrt{45}}, \frac{2}{\sqrt{45}}$ and $\frac{5}{\sqrt{45}}$

2. The unit vector parallel to the resultant of the vectors $\vec{A} = 4\hat{i} + 3\hat{j} + 6\hat{k}$ and $\vec{B} = -\hat{i} + 3\hat{j} - 8\hat{k}$ is
   (a) $\frac{1}{7}(3\hat{i} + 6\hat{j} - 2\hat{k})$
   (b) $\frac{1}{7}(3\hat{i} + 6\hat{j} + 2\hat{k})$
   (c) $\frac{1}{49}(3\hat{i} + 6\hat{j} - 2\hat{k})$
   (d) $\frac{1}{49}(3\hat{i} - 6\hat{j} + 2\hat{k})$

3. The vectors from origin to the points A and B are $\vec{A} = 3\hat{i} - 6\hat{j} + 2\hat{k}$ and $\vec{B} = 2\hat{i} + \hat{j} - 2\hat{k}$ respectively. The area of the triangle OAB be
   (a) $\frac{5}{2}\sqrt{17}$ sq. unit
   (b) $\frac{2}{5}\sqrt{17}$ sq.unit
   (c) $\frac{3}{5}\sqrt{17}$ sq. unit
   (d) $\frac{5}{3}\sqrt{17}$ sq.unit

4. If C and R represent capacitance and resistance respectively, then the dimensions of RC are
   (a) $[M^0L^0T^2]$
   (b) $[M^0L^0T]$
   (c) $[ML^{-1}]$
   (d) none of these

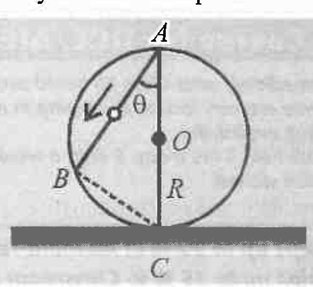
5. The equation of state of some gases can be expressed as $\left(P + \frac{a}{V^2}\right)(V - b) = RT$. Here P is the pressure, V is the volume, T is the absolute temperature and a,b,R are constants. The dimensions of 'a' are
   (a) $[ML^5T^{-2}]$
   (b) $[ML^{-1}T^{-2}]$
   (c) $[M^0L^3T^0]$
   (d) $[M^0L^6T^0]$

6. A physical parameter a can be determined by measuring the parameters b, c, d and e using the relation $a = b^\alpha c^\beta / d^\gamma e^\delta$. If the maximum errors in the measurement of b, c, d and e are $b_1\%$, $c_1\%$, $d_1\%$ and $e_1\%$, then the maximum error in the value of a determined by the experiment is
   (a) $(b_1 + c_1 + d_1 + e_1)\%$
   (b) $(b_1 + c_1 - d_1 - e_1)\%$
   (c) $(\alpha b_1 + \beta c_1 - \gamma d_1 - \delta e_1)\%$
   (d) $(\alpha b_1 + \beta c_1 + \gamma d_1 + \delta e_1)\%$

7. A person travels along a straight road for the first half time with a velocity v_1 and the next half time with a velocity v_2. The mean velocity v of the man is
   (a) $\frac{2}{v} = \frac{1}{v_1} + \frac{1}{v_2}$
   (b) $v = \frac{v_1 + v_2}{2}$
   (c) $v = \sqrt{v_1 v_2}$
   (d) $v = \sqrt{\frac{v_1}{v_2}}$

8. Two cars A and B are travelling in the same direction with velocities v_1 and v_2 ($v_1 > v_2$). When the car A is at a distance d ahead of the car B, the driver of the car A applied the brake producing a uniform retardation a. There will be no collision when
   (a) $d < \frac{(v_1 - v_2)^2}{2a}$
   (b) $d < \frac{v_1^2 - v_2^2}{2a}$
   (c) $d > \frac{(v_1 - v_2)^2}{2a}$
   (d) $d > \frac{v_1^2 - v_2^2}{2a}$

9. A frictionless wire AB is fixed on a sphere of radius R. A very small spherical ball slips on this wire. The time taken by this ball to slip from A to B is



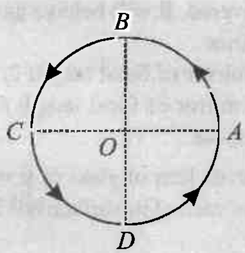
(a) $\frac{2\sqrt{gR}}{g\cos\theta}$ (b) $2\sqrt{gR}\frac{\cos\theta}{g}$

(c) $2\sqrt{\frac{R}{g}}$ (d) $\frac{gR}{\sqrt{g\cos\theta}}$

10. A body is revolving with a constant speed along a circle. If its direction of motion is reversed but the speed remains the same, then which of the following statement is true?
(a) The magnitude of centripetal force is variable
(b) The centripetal force will have its direction reversed
(c) The centripetal force will not suffer any change in direction
(d) The centripetal force would be doubled

11. The angular speed of seconds needle in a mechanical watch is
(a) $\frac{\pi}{30}$ rad/s (b) 2π rad/s
(c) π rad/s (d) $\frac{60}{\pi}$ rad/s

12. Figure shows a body of mass m moving with a uniform speed v along a circle of radius r. The change in velocity in going from A to B is



(a) $v\sqrt{2}$ (b) $v/\sqrt{2}$
(c) v (d) zero

13. A body of mass 5 kg starts from the origin with an initial velocity $\vec{u} = 30\hat{i} + 40\hat{j}\,\text{ms}^{-1}$. If a constant force $\vec{F} = -(\hat{i} + 5\hat{j})$N acts on the body, the time in which the y-component of the velocity becomes zero is
(a) 5 sec (b) 20 sec
(c) 40 sec (d) 80 sec

14. A block of mass 5 kg is on a rough horizontal surface and is at rest. Now a force of 24 N is imparted to it with negligible impulse. If the coefficient of kinetic friction is 0.4 and $g = 9.8$ m/s^2, then the acceleration of the block is
(a) 0.26 m/s^2 (b) 0.39 m/s^2
(c) 0.69 m/s^2 (d) 0.88 m/s^2

15. A vehicle of mass m is moving on a rough horizontal road with momentum p. If the coefficient of friction between the tyres and the road be μ, then the stopping distance is
(a) $\frac{p}{2\mu mg}$ (b) $\frac{p^2}{2\mu mg}$
(c) $\frac{p}{2\mu m^2 g}$ (d) $\frac{p^2}{2\mu m^2 g}$

16. A given object takes n times as much time to slide down a 45° rough inclined as it takes to slide down a perfectly smooth 45° incline. The coefficient of kinetic friction between the object and the incline is given by
(a) $\left(1-\frac{1}{n^2}\right)$ (b) $\frac{1}{1-n^2}$
(c) $\sqrt{\left(1-\frac{1}{n^2}\right)}$ (d) $\sqrt{\frac{1}{1-n^2}}$

17. A particle of mass m moving with velocity v_0 strikes a simple pendulum of mass m and sticks to it. The maximum height attained by the pendulum will be
(a) $\frac{v_0^2}{8g}$ (b) $\sqrt{v_0 g}$
(c) $2\sqrt{\frac{v_0}{g}}$ (d) $\frac{v_0^2}{4g}$

18. A car of mass 1250 kg is moving at 30 m/s. Its engine delivers 30 kW while resistive force due to surface is 750 N. What maximum acceleration can be given in the car?
(a) $\frac{1}{3}$ m/s^2 (b) $\frac{1}{4}$ m/s^2
(c) $\frac{1}{5}$ m/s^2 (d) $\frac{1}{6}$ m/s^2

19. A space craft of mass M is moving with velocity v and suddenly explodes into two pieces. A part of it of mass m comes at rest, then the velocity of other part will be
(a) $\frac{Mv}{M-m}$ (b) $\frac{Mv}{M+m}$
(c) $\frac{mv}{M-m}$ (d) $\frac{(M+m)v}{m}$

20. A bullet of mass m moving with velocity v strikes a block of mass M at rest and gets embedded into it. The kinetic energy of the composite block will be
(a) $\frac{1}{2}mv^2 \times \frac{m}{(m+M)}$ (b) $\frac{1}{2}mv^2 \times \frac{M}{(m+M)}$

(c) $\frac{1}{2}mv^2 \times \frac{(M+m)}{M}$ (d) $\frac{1}{2}Mv^2 \times \frac{m}{(m+M)}$

21. When a plane mirror is placed horizontally on a level ground at a distance of 60 m from the foot of a tower, the top of the tower and its image in the mirror subtend an angle of 90° at the eye. The height of the tower will be

(a) 30 m (b) 60 m
(c) 90 m (d) 120 m

22. A light beam is being reflected by using two mirrors, as in a periscope used in submarines. If one of the mirrors rotates by an angle θ the reflected light will deviate from its original path by the angle

(a) 2θ (b) 0°
(c) θ (d) 4θ

23. The relation between the linear magnification m, the object distance u and the focal length f is

(a) $m = \frac{f-u}{f}$ (b) $m = \frac{f}{f-u}$
(c) $m = \frac{f+u}{f}$ (d) $m = \frac{f}{f+u}$

24. Radius of curvature of concave mirror is 40 cm and the size of image is twice as that of object, then the object distance is

(a) 60 cm (b) 20 cm
(c) 40 cm (d) 30 cm

25. A point object is placed at a distance of 10 cm and its real image is formed at a distance of 20 cm from a concave mirror. If the object is moved by 0.1 cm towards the mirror, the image will shift by about

(a) 0.4 cm away from the mirror
(b) 0.4 cm towards the mirror
(c) 0.8 cm away from the mirror
(d) 0.8 cm towards the mirror

26. Monochromatic light is refracted from air into the glass of refractive index μ. The ratio of the wavelength of incident and refracted waves is

(a) 1 : μ (b) 1 : μ² (c) μ : 1 (d) 1: 1

27. If μ_0 be the relative permeability and K_0 the dielectric constant of a medium, its refractive index is given by

(a) $\frac{1}{\sqrt{\mu_0 K_0}}$ (b) $\frac{1}{\mu_0 K_0}$
(c) $\sqrt{\mu_0 K_0}$ (d) $\mu_0 K_0$

28. On a glass plate a light wave is incident an angle of 60°. If the reflected and the refracted waves are mutually perpendicular, then refractive index of material is

(a) $\frac{\sqrt{3}}{2}$ (b) $\sqrt{3}$ (c) $\frac{3}{2}$ (d) $\frac{1}{\sqrt{3}}$

29. The wavelength of sodium light in air is 5890 Å. The velocity of light in air is 3×10^8 ms^{-1}. The wavelength of light in a glass of refractive index 1.6 would be close to

(a) 5890 Å (b) 3681 Å
(c) 9424 Å (d) 15078 Å

30. Total internal reflection of a ray of light is possible when the (i_c = critical angle, i = angle of incidence)

(a) ray goes from denser medium to rarer medium and $i < i_c$
(b) ray goes from denser medium to rarer medium and $i > i_c$
(c) ray goes from rarer medium to denser medium and $i > i_c$
(d) ray goes from rarer medium to denser medium and $i < i_c$

31. A diver at a depth of 12 m in water (μ = 4/3) sees the sky in a cone of semi-vertical angle

(a) $\sin^{-1}$ (4/3) (b) $\tan^{-1}$ (4/3)
(c) $\sin^{-1}$ (3/4) (d) 90°

32. The plane surface of a plano-convex lens of focal length f is silvered. It will behave as

(a) plane mirror
(b) convex mirror of focal length $2f$
(c) concave mirror of focal length $f/2$
(d) none of these

33. A double convex lens of glass of μ = 1.5 has radius of curvature of each of its surface is 0.2 m. The power of the lens is

(a) + 10 dioptre (b) – 10 dioptre
(c) – 5 dioptre (d) + 5 dioptre

34. The critical angle between an equilateral prism and air is 42°. If the incident ray is perpendicular to the refracting surface, then

(a) After deviation it will emerge from the second refracting surface
(b) It is totally reflected on the second surface and emerges out perpendicularly from third surface in air
(c) It is totally reflected from the second and third refracting surfaces and finally emerges out from the first surface
(d) It is totally reflected from all the three sides of prism and never emerges

35. If the refractive indices of crown glass for red, yellow and violet colours are 1.5140, 1.5170 and 1.5318

respectively and for flint glass these are 1.6434, 1.6499 and 1.6852 respectively, then the dispersive powers for crown and flint glass are respectively

(a) 0.034 and 0.064 (b) 0.064 and 0.034
(c) 1.00 and 0.064 (d) 0.034 and 1.0

36. If the refractive indices of a prism for red, yellow and violet colours be 1.61, 1.63 and 1.65 respectively, then the dispersive power of the prism will be

(a) $\frac{1.65-1.62}{1.61-1}$ (b) $\frac{1.62-1.61}{1.65-1}$
(c) $\frac{1.65-1.61}{1.63-1}$ (d) $\frac{1.65-1.63}{1.61-1}$

37. A prism of refractive index μ and angle A is placed in the minimum deviation position. If the angle of minimum deviation is A, then the value of A in terms of μ is

(a) $\sin^{-1}\left(\frac{\mu}{2}\right)$ (b) $\sin^{-1}\sqrt{\frac{\mu-1}{2}}$
(c) $2\cos^{-1}\left(\frac{\mu}{2}\right)$ (d) $\cos^{-1}\left(\frac{\mu}{2}\right)$

38. In a compound microscope, if the objective produces an image I_o and the eye piece produces an image I_e, then

(a) I_o is virtual but I_e is real
(b) I_o is real but I_e is virtual
(c) I_o and I_e are both real
(d) I_o and I_e are both virtual

39. The focal lengths of the objective and the eye-piece of a compound microscope are 2.0 cm and 3.0 cm respectively. The distance between the objective and the eye-piece is 15.0 cm. The final image formed by the eye-piece is at infinity. The two lenses are thin. The distances in cm of the object and the image produced by the objective measured from the objective lens are respectively

(a) 2.4 and 12.0 (b) 2.4 and 15.0
(c) 2.3 and 12.0 (d) 2.3 and 3.0

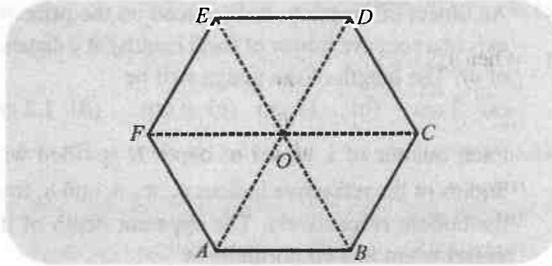
40. If F_o and F_e are the focal length of the objective and eyepiece respectively of a telescope, then its magnifying power will be

(a) $F_o + F_e$ (b) $F_o \times F_e$
(c) F_o / F_e (d) $\frac{1}{2}(F_o + F_e)$

41. Five equal forces of 10 N each are applied at one point and all are lying in one plane. If the angles between them are equal, the resultant force will be

(a) zero (b) 10 N (c) 20 N (d) $10\sqrt{2}$ N

42. Figure shows $ABCDEF$ as a regular hexagon. What is the value of $\overrightarrow{AB}+\overrightarrow{AC}+\overrightarrow{AD}+\overrightarrow{AE}+\overrightarrow{AF}$

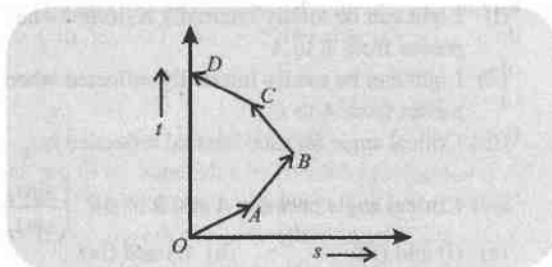


(a) $\overrightarrow{OA}$ (b) $2\overrightarrow{AO}$ (c) $4\overrightarrow{AO}$ (d) $6\overrightarrow{AO}$

43. The frequency of vibration of string is given by $\upsilon = \frac{p}{2l}\left[\frac{F}{m}\right]^{1/2}$. Here p is number of segments in the string and l is the length. The dimensional formula for m will be

(a) $[M^0LT^{-1}]$ (b) $[ML^0T^{-1}]$
(c) $[ML^{-1}T^0]$ (d) $[M^0L^0T^0]$

44. Which of the following options is correct for the object having a straight line motion represented by the following graph?



(a) The object moves with constantly increasing velocity from O to A and then it moves with constant velocity.
(b) Velocity of the object increases uniformly.
(c) Average velocity is zero.
(d) The graph shown is impossible.

45. The motion of a body is given by the equation $\frac{dv(t)}{dt} = 6.0 - 3v(t)$, where $v(t)$ is speed in m/s and t in sec. If body was at rest at $t = 0$

(a) The terminal speed is 4.0 m/s
(b) The speed varies with the time as $v(t) = 2(1 - e^{-3t})$ m/s
(c) The speed is 0.1 m/s when the acceleration is half the initial value
(d) The magnitude of the initial acceleration is 3.0 m/s^2

46. Two plane mirrors are inclined at an angle of 72°. The number of images of a point object placed between them will be

(a) 2 (b) 3 (c) 4 (d) 5

47. An object of length 6 cm is placed on the principle axis of a concave mirror of focal length f at a distance of $4f$. The length of the image will be
(a) 2 cm (b) 12 cm (c) 4 cm (d) 1.2 cm

48. Each quarter of a vessel of depth H is filled with liquids of the refractive indices n_1, n_2, n_3 and n_4 from the bottom respectively. The apparent depth of the vessel when looked normally is

(a) $\dfrac{H(n_1+n_2+n_3+n_4)}{4}$

(b) $\dfrac{H\left(\frac{1}{n_1}+\frac{1}{n_2}+\frac{1}{n_3}+\frac{1}{n_4}\right)}{4}$

(c) $\dfrac{(n_1+n_2+n_3+n_4)}{4H}$

(d) $\dfrac{H\left(\frac{1}{n_1}+\frac{1}{n_2}+\frac{1}{n_3}+\frac{1}{n_4}\right)}{2}$

49. Material A has critical angle i_A, and material B has critical angle i_B $(i_B > i_A)$. Then which of the following is true?
(i) Light can be totally internally reflected when it passes from B to A
(ii) Light can be totally internally reflected when it passes from A to B
(iii) Critical angle for total internal reflection is $i_B - i_A$
(iv) Critical angle between A and B is $\sin^{-1}\left(\dfrac{\sin i_A}{\sin i_B}\right)$
(a) (i) and (iii) (b) (i) and (iv)
(c) (ii) and (iii) (d) (ii) and (iv)

50. A thin lens made of glass of refractive index 1.5 has a front surface + 11 D power and back surface – 6 D. If this lens is submerged in a liquid of refractive index 1.6, the resulting power of the lens is
(a) – 0.5 D (b) + 0.5 D
(c) – 0.625 D (d) + 0.625 D

CHEMISTRY

51. The maximum kinetic energy of photoelectrons ejected from a metal is 4×10^{-19} J when it is irradiated with radiation of frequency twice the threshold frequency. The threshold wavelength of the metal is about
(a) 400 nm (b) 500 nm
(c) 600 nm (d) 300 nm

52. The orbital diagram in which the aufbau principle is violated is

(a) 2s [↑↓] 2p [↑↓][↑][ ] (b) 2s [↑] 2p [↑↓][↑][↑]
(c) 2s [↑↓] 2p [↑][↑][↑] (d) 2s [↑↓] 2p [↑↓][↑↓][↑]

53. The expression of Rydberg constant is
(a) $2\pi^2 mh^3c/(e^2/4\pi\varepsilon_0)^2$ (b) $2\pi^2 m(e^2/4\pi\varepsilon_0)^2/h^3c$
(c) $(e^2/4\pi\varepsilon_0)^2/2\pi^2 mh^3c$ (d) $2\pi^2 mh^3c/(e^2/4\pi\varepsilon_0)$

54. The velocity of an electron in the first Bohr orbit of hydrogen atom is 2.19×10^6 ms^{-1}. Its velocity in the second orbit would be
(a) 1.10×10^6 ms^{-1} (b) 4.38×10^6 ms^{-1}
(c) 5.5×10^5 ms^{-1} (d) 8.76×10^6 ms^{-1}

55. Which of the following orbitals is symmetric about the y-axis ?
(a) p_x (b) p_y (c) $d_{x^2-y^2}$ (d) d_{xy}

56. The first ionization potential of Na, Mg, Al and Si are in the order
(a) Na < Mg > Al < Si (b) Na > Mg > Al > Si
(c) Na < Mg < Al > Si (d) Na > Mg > Al < Si

57. The correct order of third ionization energies (IE_3) of Na, Mg and Al is
(a) Mg > Na > Al (b) Al > Mg > Na
(c) Na > Mg > Al (d) Mg > Al > Na

58. The correct order of ionization energy is
(a) Si > P > S (b) Si > P < S
(c) Si < P > S (d) Si < P < S

59. Which of the element is a metalloid ?
(a) C (b) As (c) Pb (d) Mg

60. The molecule having one unpaired electron is
(a) NO (b) CO (c) CN^- (d) O_2

61. The hybridization in sulphur dioxide is
(a) sp (b) sp^2 (c) sp^3 (d) dsp^2

62. The species in which the central atom uses sp^2 hybrid orbitals in its bonding is
(a) PH_3 (b) NH_3 (c) CH_3^+ (d) SbH_3

63. The ion that is isoelectronic with CO is
(a) CN^- (b) O_2^+ (c) O_2^- (d) N_2^+

64. Which of the following is paramagnetic ?
(a) O_2^- (b) CN^- (c) CO (d) NO^+

65. If 0.6 mol of $BaCl_2$ is mixed with 0.30 mol of Na_3PO_4. The maximum amount of $Ba_3(PO_4)_2$ that can be formed is
(a) 0.70 mol (b) 0.50 mol
(c) 0.20 mol (d) 0.15 mol

66. A mixture weighing 4.08 g of BaO (molar mass of Ba = 138 g mol^{-1}) and unknown carbonate XCO_3

was heated strongly. The residue weighed 3.64 g. This was dissolved in 100 mL of 1 M HCl. The excess acid required 16 mL of 2.5 M NaOH solution for complete neutralization. The molar mass X is about
(a) 20 g mol^{-1} (b) 30 g mol^{-1}
(c) 40 g mol^{-1} (d) 50 g mol^{-1}

67. Assuming complete dissociation of H_2SO_4 as
($H_2SO_4 + 2H_2O \rightarrow 2H_3O^+ + SO_4^{2-}$)
The number of H_3O^+ ions in 10 ml of 0.5 N H_2SO_4 is
(a) 3.01×10^{21} (b) 1.5×10^{21}
(c) 6.02×10^{21} (d) 3.01×10^{22}

68. Three of the following formulae might be empirical or molecular formulae but the fourth is certainly a molecular formula. Which one is that ?
(a) N_2O (b) N_2O_4 (c) NH_3 (d) Mg_3N_2

69. Given the following reaction at equilibrium. $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$. Some inert gas at constant pressure is added to the system. Predict which of the following fact will be affected ?
(a) More $NH_{3(g)}$ is produced
(b) Less $NH_{3(g)}$ is produced
(c) No affect on the equilibrium
(d) K_p of the reaction is decreased

70. For the reaction $NO_{2(g)} + O_{2(g)} \rightleftharpoons 2N_2O_{5(g)}$, which of the following fact holds good ?
(a) $K_p = K_c$ (b) $K_p > K_c$
(c) $K_p < K_c$
(d) K_p and K_c cannot be correlated unless pressure of the system is provided.

71. Solids $CaCO_3$ and CaO and gaseous CO_2 are placed in a vessel and allowed to reach equilibrium $CaO_{(s)} + CO_{2(g)} \rightleftharpoons CaCO_{3(s)}$ $\Delta H = -180$ kJ mol^{-1}
The quantity of CaO in the vessel could be increased by
(a) adding more of $CaCO_3$
(b) removing some of CO_2
(c) lowering the temperature
(d) reducing the volume of the vessel

72. In a system $A_{(s)} \rightleftharpoons 2B_{(g)} + 3C_{(g)}$, if the concentration of C at equilibrium is increased by a factor of 2, it will cause the equilibrium concentration of B change to
(a) two times the original value
(b) one half of its original value
(c) $2\sqrt{2}$ times its original value
(d) $1/2\sqrt{2}$ times the original value

73. The half-life period of a radioactive element is 140 days. After 560 days, one gram of the element will reduce to
(a) 1/2 g (b) 1/4 g (c) 1/8 g (d) 1/16 g

74. For an endothermic reaction where ΔH represents the enthalpy of the reaction, the minimum value for the energy of activation will be
(a) less than ΔH (b) zero
(c) more than ΔH (d) equal to ΔH

75. The plot of log K versus $1/T$ is linear with a slope of
(a) E_a/R (b) $-E_a/R$
(c) $E_a/2.303R$ (d) $-E_a/2.303R$

76. For the decomposition of $N_2O_{5(g)}$, it is given that
$2N_2O_{5(g)} \rightarrow 4NO_{2(g)} + O_{2(g)}$; activation energy, E_a
$N_2O_{5(g)} \rightarrow 2NO_{2(g)} + \frac{1}{2}O_{2(g)}$; activation energy E_a' then
(a) $E_a = E_a'$ (b) $E_a > E_a'$
(c) $E_a < E_a'$ (d) $E_a = 2E_a'$

77. 0.1 mol of HCl is added to 1L of solution containing 0.5 mol of sodium acetate. The pH of the solution will be
(a) 1.0 (b) 4.74 (c) 5.35 (d) 4.15
(Given : $K_{a\,(CH_3COOH)} = 1.8 \times 10^{-5}$)

78. The ratio of acid strength of HOCN and HCN is about (Given : $K_{a(HCN)} = 4.2 \times 10^{-10}$ M and $K_{a(HOCN)} = 1.2 \times 10^{-4}$ M)
(a) 548 : 1 (b) 1 : 548
(c) $2.86 \times 10^5 : 1$ (d) $2.86 \times 10^4 : 1$

79. If pK_b for fluoride ion at 25°C is 10.83, the ionization constant of HF in water at this temperature is
(a) 1.74×10^{-5} (b) 3.52×10^{-3}
(c) 6.75×10^{-4} (d) 5.38×10^{-2}

80. 40.25 g of Glauber's salt is dissolved in water to obtain 500 mL of solution of density 1077.5 g dm^{-3}. The molality of Na_2SO_4 in solution is about
(a) 0.25 mol kg^{-1} (b) 0.24 mol kg^{-1}
(c) 0.26 mol kg^{-1} (d) 0.27 mol kg^{-1}

81. Mixing of 50 mL of 0.25 M lead nitrate solution with 25 mL of 0.10 M chromic sulphate solution causes the precipitation of lead sulphate. The molarity of Pb^{2+} and Cr^{3+} ions in the solution respectively are
(a) 0.0667 M, 0.0667 M (b) 0.1 M, 0.2 M
(c) 0.125 M, 0.05 M (d) 0.05 M, 0.125 M

82. A solution containing Na_2CO_3 and $NaHCO_3$ is titrated against 0.1 M HCl solution using methyl orange indicator. At the equivalence point,
(a) both Na_2CO_3 and $NaHCO_3$ are completely

neutralized
(b) only Na_2CO_3 is wholly neutralized
(c) only $NaHCO_3$ is wholly neutralized
(d) $NaCO_3$ is neutralized upto the stage of $NaHCO_3$

83. Benzene (p^0 = 160 mm) and toluene (p^0 = 68 mm) form ideal solution at certain temperature with mole fraction of benzene as 0.2. The vapour pressure of solution will be
(a) 220 mm (b) 86.4 mm
(c) 160 mm (d) cannot be predicted

84. The elevation in boiling point of solution of 9.5 g $MgCl_2$ in 1 kg water using the following information will be (molecular weight of $MgCl_2$ = 95, K_b = 0.52 K molality^{-1})
(a) 0.16 (b) 0.05 (c) 0.1 (d) 0.2

85. Air contains 79% N_2 and 21% O_2 by volume. If pressure is 750 mm of Hg, the partial pressure of oxygen is
(a) 175 mm of Hg (b) 157.5 mm of Hg
(c) 320 mm of Hg (d) 250 mm of Hg

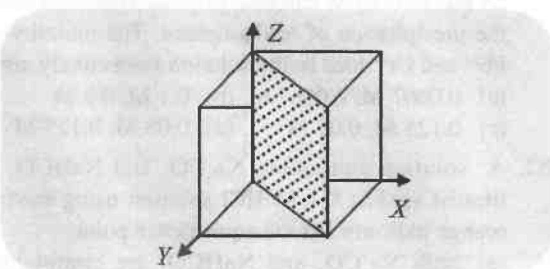
86. The density of neon will be highest at
(a) STP (b) 0°C, 2 atm
(c) 273°C, 1 atm (d) 273°C, 2 atm

87. The rate of diffusion of methane at a given temperature is twice that of a gas *X*. The molecular weight of *X* is
(a) 64.0 (b) 32.0 (c) 4.0 (d) 8.0

88. An alloy of gold and copper crystallises in a cubic lattice in which gold atoms occupy the lattice points at the corner of the cube and copper atoms occupy centres of each of the cube faces. The probable empirical formula of an alloy is
(a) Au_3Cu (b) $AuCu_3$ (c) Au_2Cu_3 (d) $AuCu_2$

89. If the anions (*A*) form hexagonal closest packing and cations (*C*) occupy only 2/3 octahedral voids in it, then the general formula of the compound is
(a) CA (b) CA_2 (c) C_2A_3 (d) C_3A_2

90. Miller indices of the shaded plane shown in the diagram

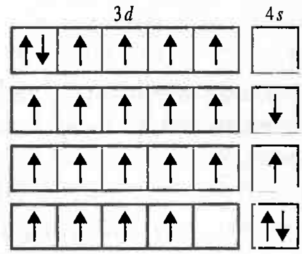


(a) 001 (b) 111 (c) 110 (d) 100

91. The ionization energy of the ground-state hydrogen atom is 2.18 × 10^{18} J. The energy of an electron in its second orbit would be
(a) -1.09×10^{-18} J (b) -2.18×10^{-18} J
(c) -4.36×10^{-18} J (d) -5.45×10^{-19} J

92. Which of the following arrangement of electrons is most likely to be stable ?

(a)
(b)
(c)
(d)



93. Pick out the isoelectronic structures from the following :
I. CH_3^+ II. H_3O^+ III. NH_3 IV. CH_3^-
(a) I and II (b) III and IV
(c) I and III (d) II, III and IV

94. The molecular electronic configuration of B_2 is
(a) $KK\,(\sigma 2s)^2(\sigma^*2s)^2(\pi 2p_x)^1(\pi 2p_y)^1$
(b) $KK\,(\sigma 2s)^2(\sigma^*2s)^2(\pi 2p_x)^2$
(c) $KK\,(\sigma 2s)^2(\sigma^*2s)^2(\pi 2p_y)^2$
(d) $KK\,(\sigma 2s)^2(\sigma^*2s)^2(\sigma 2p_x)^1(\pi 2p_y)^1$

95. The expression relating mole fraction of solute (x_2) and molarity (*M*) of the solution is
(a) $x_2 = \dfrac{MM_1}{M(M_1 - M_2) + \rho}$
(b) $x_2 = \dfrac{MM_1}{M(M_1 - M_2) - \rho}$
(c) $x_2 = \dfrac{M(M_1 - M_2) + \rho}{MM_1}$
(d) $x_2 = \dfrac{M(M_1 - M_2) - \rho}{MM_1}$

96. The equilibrium constant K_c of the reaction $A_{2(g)} + B_{2(g)} \rightleftharpoons 2AB_{(g)}$ is 50. If 1 mol of A_2 and 2 mol of B_2 are mixed, the amount *AB* at equilibrium would be
(a) 0.467 mol (b) 0.934 mol
(c) 1.401 mol (d) 1.866 mol

97. For a chemical reaction $X \rightarrow Y$, the rate of reaction increases by a factor of 1.837 when the concentration of *X* is increased by 1.5 times. The order of the reaction with respect to *X* is

(c) apogamy (d) amphimixis

119. Effect of foreign pollen on endosperm is
(a) chimera (b) xenia
(c) metaxenia (d) polyploidy

120. The total nuclei in mature male gametophyte of an angiosperm are
(a) two (b) three (c) four (d) five

121. Crucifer ovule is
(a) atropous (b) campylotropous
(c) anatropous (d) circinotropous

122. 8-nucleated embryosacs are
(a) monosporic only (b) bisporic only
(c) tetrasporic (d) any of these

123. In an embryo, the radicle is near the
(a) micropyle (b) chalaza
(c) hilum (d) funicle

124. The ephemeral structure which anchors the embryo and pushes it into the nutritional zone of the embryosac
(a) haustorium (b) suspensor
(c) coleorhiza (d) radicle

125. One of the following guide the pollen tube in releasing gametes in embryosac
(a) synergid (b) secondary nucleus
(c) egg cell (d) antipodal cell

126. Photorespiration in C_3 plants starts from
(a) Phosphoglycerate (b) Phosphoglycolate
(c) Glycerate (d) Glycine

127. Which type of reaction changes pyruvate to acetyl CoA ?
(a) Oxidative decarboxylation
(b) Oxidative dehydrogenation
(c) Oxidative dehydration
(d) Oxidative phosporylation

128. Pyruvic acid before combining with the oxaloacetic acid of citric acid cycle change into
(a) 4 carbon compound (b) 3 carbon compound
(c) 2 carbon compound (d) 6 carbon compound

129. The approximate amount of energy received from one bond breakage of molecule of ATP is
(a) 76 kcal (b) 7.6 kcal
(c) 6.7 kcal (d) 67 kcal.

130. Which of the following occurs only in aerobic conditions ?
(a) Glycolysis
(b) Oxidative phosphorylation
(c) Fermentation
(d) Lactate respiration

131. Largest amount of phosphate bond energy is produced in the process of respiration during
(a) glycolysis (b) Kreb's cycle
(c) anaerobic respiration (d) none of these

132. Photorespiration take place in plants where carbon fixation occurs through
(a) Calvin cycle (b) Hatch Slack cycle
(c) glycolysis (d) Kreb's cycle.

133. Total ATP production during EMP pathway is
(a) 24 ATP molecules (b) 8 ATP molecules
(c) 38 ATP molecules (d) 15 ATP molecules

134. If there is increase in temperature of about more than 35°C
(a) rate of decline of respiration will be earlier than decline of photosynthesis
(b) rate of decline of photosynthesis be earlier than decline of respiration
(c) both decline together
(d) both show no fixed variations.

135. R.Q. of $C_{18}H_{32}O_{16}$ is
(a) 0.715 (b) 1.00 (c) 1.430 (d) 2.145

136. During conversion of pyruvic acid to acetyl CoA – are also formed
(a) CO_2 and H_2O (b) CO_2 and $NADH_2$
(c) CO_2 and NAD (d) CO_2 and O_2

137. The number of glucose molecules required to produce 38 ATP molecules under anaerobic conditions by any yeast cell is
(a) 2 (b) 1 (c) 19 (d) 38

138. What is common in NAD, ATP and FMN ?
(a) Zn (b) P (c) Ca (d) Mg.

139. NADPH and ATP are generated through
(a) anaerobic respiration (b) glycolysis
(c) photosystem I (d) photosystem II

140. In anaerobic fermentation 15% of the energy is stored as ATP and 50% of it is lost as heat. The remaining energy is used in
(a) doing work
(b) growth and reproduction of yeast cells
(c) fast locomotion
(d) production of oxygen

141. In anaerobic respiration of yeast and bacteria, which of the following is released ?
(a) Methanol (b) CO_2
(c) Butanol (d) H_2O

142. Osmotic pressure depends upon
(a) concentration of solute
(b) ionisation of solute
(c) temperature (d) all of these

143. Which of the following has the highest water

potential (Ψ)
(a) 1 M salt solution (b) 1 M sugar solution
(c) 1 M sugar solution with 2.3 bars pressure applied on it
(d) Distilled water

144. 0.5 M sucrose solution develops a pressure of 15 bars in an osmometer. Which of the following statement is wrong for such a solution ? Its
(a) osmotic potential is – 15 bars
(b) water potential is – 15 bars
(c) pressure potential is – 15 bars
(d) osmotic pressure is + 15 bars

145. 0.1 M solution of a solute has a water potential of
(a) – 2.3 bars (b) 0 bar
(c) 22.4 bars (d) + 2.3 bars

146. Stump of well watered potted plant shows exudation of sap due to
(a) root pressure (b) capillary
(c) cohesion force (d) transpiration pull.

147. Root hairs absorb water from soil through
(a) turgor pressure (b) ion exchange
(c) osmosis (d) DPD

148. Field capacity is affected by
(a) soil profile (b) soil structure
(c) temperature (d) all of these

149. Cobalt chloride is blue in dry state. In contact with moisture, it turns
(a) yellow (b) pink (c) green (d) red

150. Main function of lenticels is
(a) transpiration (b) guttation
(c) gaseous exchange (d) translation

151. Yellow bone marrow is found especially in the medullary cavity of
(a) spongy bones (b) long bones
(c) short bones (d) all of these

152. Transitional epithelium is found in
(a) lungs (b) liver
(c) urinary bladder (d) stomach

153. Heparin is secreted by
(a) liver cell (b) mast cell
(c) nervous cell (d) kidney

154. Adam's apple represents
(a) cartilage of larynx
(b) thyroid cartilage of trachea
(c) both (a) and (b) (d) none of these

155. Cartilage is
(a) non-vascular (b) highly vascular
(c) poorly vascular (d) none of these

156. Haemoglobin first appears in which stage of RBC development
(a) Erythrocytoblast (b) Normoblast
(c) Reticulocyte (d) Erythrocyte

157. Relative volume of erythrocyte may be read as percentage of total blood volume in the graduated centrifuge tube (Haematocrit tube)
(a) PCV (b) ESR
(c) TLC (d) all of these

158. Thromboplastin changes into Prothrombokinase in presence of calcium ion, now prothrombokinase helps in clotting of blood by
(a) inactivation of heparin
(b) conversion of prothrombin into thrombin
(c) conversion of fibrinogen into fibrin
(d) both (a) and (b)

159. Which of the following is used as artificial anticoagulant and precipitates calcium ion in test-tube during blood examination?
(a) citrate or oxalate of Na
(b) citrate or oxalate of K
(c) citrate or oxalate of Cs
(d) both (a) and (b)

160. Blood differ from lymph in
(a) containing less lymphocyte & waste
(b) containing large protein
(c) containing RBC (d) all of these

161. Which of the following layer of epidermis in man provides the main protection of body against water loss and the entry of disease causing organism?
(a) *Stratum spirosum* (b) *Stratum corneum*
(c) *Stratum lucidium* (d) *Stratum germinativum*

162. Camouflage of Chameleon is associated with
(a) chromosome (b) chromomere
(c) chromoplast (d) chromatophore

163. Pacinian corpuscles occur in the skin of certain parts of body in mammals. These are
(a) type of glands (b) pain receptors
(c) naked tactile receptors
(d) encapsulated pressure receptors

164. Epidermis is specialized for
(a) respiration (b) absorption
(c) protection (d) all of these

165. Erector pilli associated with base of hair follicle is
(a) single unit, involuntary
(b) multi unit, involuntary
(c) single unit, voluntary
(d) multi unit, voluntary

166. Greenish faecal matter passed by infant in first two days of birth due to sterilized intestine is
(a) macrophage (b) stercobilin

(c) meconium (d) both (b) and (c).

167. The term given to rythmic waves of contraction passing backwards over the gut wall resulting in the pushing of the food is
(a) regurgitation (b) emulsification
(c) peristalsis (d) deglutination.

168. ..... among the following are not deciduous
(a) incisors (b) canines
(c) premolars (d) Ist and 2nd molars

169. Eating of raw fish can cause deficiency of vitamin
(a) D (b) B_6 (c) B_1 (d) K

170. Cloacal thymus is another name of
(a) cloaca of birds
(b) endostyle of protochordates
(c) bursa Fabricius (d) thymus of man.

171. Mumps is the painful condition of
(a) sublingula infection (b) parotid infection
(c) submaxillary salivary glands
(d) all of these

172. Cow's milk is more nutritious and slightly yellow due to presence of
(a) vitamin D (b) ascorbic acid
(c) riboflavin (d) tryptophan

173. Surfactant dipalmityl lecithin of the lungs is released by
(a) histiocytes of the lungs
(b) Kupffer cells of the liver
(c) Clara cells of the lungs
(d) both (a) and (c)

174. The end product of anaerobic respiration, in animals, is
(a) pyruvic acid (b) malic acid
(c) lactic acid (d) methyl alcohol

175. Haemoglobin oxygen dissociation curve in developing foetus is
(a) sigmoid (b) hyperbola
(c) parabola (d) none of these

176. The intestinal villi are more numerous and larger in posterior part of small intestine than in anterior part, because
(a) blood supply is poorer in anterior part
(b) there is more digested food in posterior part
(c) blood supply is poorer in posterior part
(d) digestion is faster in posterior part

177. The partial pressure of oxygen in the alveolar air is about
(a) 50 mm Hg (b) 101 mm Hg
(c) 150 mm Hg (d) 200 mm Hg

178. Sometimes food gets accumulated in lower part of oesophagus due to failure of cardiac sphincter. This leads to
(a) Heart burn (b) Achlorohydria
(c) Cardia achlasia (d) Deglutination

179. Aurebach's plexus is present in
(a) submucosa
(b) between mucosa and submucosa
(c) between circular and longitudinal muscles of muscularis interna
(d) between circular and longitudinal muscles of muscularis externa

180. The heart rate is increased by
(a) an increase in the activity of the sympathetic nerves that supply the heart
(b) a decrease in the activity of the parasympathetic (vagus) system
(c) an increase in the level of adrenalin in the circulation
(d) all of these.

181. During oxygen transport the oxyhaemoglobin at the tissue level liberates oxygen to the cells because in tissue
(a) O_2 concentration is high and CO_2 is low
(b) O_2 tension is low and CO_2 tension is high
(c) O_2 concentration is low and CO_2 is high
(d) O_2 tension is high and CO_2 tension is low

182. Chloride shift is essential for transport of
(a) CO_2 and O_2 (b) N_2
(c) CO_2 (d) O_2

183. The anticoagulant most commonly used to store blood in the blood banks is
(a) sodium citrate (b) sodium fluoride
(c) EDTA (d) acid citrate dextrose

184. Active bone marrow in adult human being is about
(a) 3.5 - 6% of the body weight
(b) 3.5 - 6% of total blood
(c) 3.5 - 6% of total body fluid
(d) 3.5 - 6% of coelomic fluid

185. Pacemaker of the heart in rabbit is situated in
(a) wall of right atrium close to eustachian valve
(b) interatrial septum
(c) interventricular septum
(d) wall of left atrium close to the opening of pulmonary veins

186. Severe Acute Respiratory syndrome (SARS)
(a) is caused by a variant of *Pneumococcus pneumoniae*
(b) is caused by a variant of the common cold virus (*Corona Virus*)
(c) is an acute form of asthma

(d) affects the non-vegetarian much faster than the vegetarians

187. Which statement is wrong ?
(a) Partial pressure of CO_2 (P_{CO_2}) is higher in the air inside the lungs
(b) Partial pressure of O_2 (P_{O_2}) is higher in the air inside the lungs
(c) Partial pressure of O_2 (P_{O_2}) is lower inside the venous blood than in the air in the lung
(d) Partial pressure of CO_2 (P_{CO_2}) is higher inside the venous blood than in the air

188. Which one of the following is a disease of kidney?
(a) Parkinson's disease (b) Addison's disease
(c) Bright's disease (d) Graves's disease

189. What would happen if human blood becomes acidic (low pH) ?
(a) Oxygen carrying capacity of haemoglobin increases
(b) Oxygen carrying capacity of haemoglobin decreases
(c) RBCs count increases
(d) RBCs count decreases.

190. In a cardiac output of 5250 ml per minute, with 75 heart beats per minute, the stroke volume is
(a) 55 ml (b) 60 ml (c) 70 ml (d) 80 ml

191. Which of the following vertebrate organs receives only oxygenated blood ?
(a) Gill (b) Lung (c) Liver (d) Spleen

192. Sphincter of Boyden which helps in the filling up of gall bladder is present in
(a) Ampulla of vater (b) Duct of wirsurg
(c) Ductus choledoccus (d) Duct of santorini

193. Chemical responsible for increase in blood pressure due to renin action is
(a) aldosterone (b) angiotensinogen
(c) angiotensin I (d) angiotensin II

194. Glomeruli fail to filter from plasma
(a) glucose (b) globulins
(c) lipids (d) Both (b) and (c)

195. One of the following is not a kidney disorder
(a) pyelitis (b) oedema
(c) Bright's disease (d) Paget's disease

196. Trimethylamine is excreted by
(a) marine teleosts (b) mollusca
(c) fresh water fish (d) amphibians

197. Which of the following control the amount of enzymes in pancreatic juice ?
(a) Pancreozymin (b) Secretin
(c) Cholecystokinin (d) Gastrin

198. When, under certain conditions, the P_{50} value of haemoglobin rises, the affinity of the pigment of combining with O_2 will
(a) remain same (b) rise
(c) fall (d) first rise and then fall

199. Ultrafiltration occurs in glomerulus when
(a) hydrostatic pressure is more than osmotic pressure
(b) colloidal osmotic pressure + capsular pressure is less than hydrostatic pressure
(c) osmotic pressure is more than hydrostatic pressure
(d) none of these

200. In micturition
(a) urethra relaxes (b) ureter contracts
(c) ureter relaxes (d) urethra contracts

ANSWERS

1.	(a)	2.	(a)	3.	(a)	4.	(b)	5.	(a)
6.	(d)	7.	(b)	8.	(c)	9.	(c)	10.	(c)
11.	(a)	12.	(a)	13.	(c)	14.	(d)	15.	(d)
16.	(a)	17.	(a)	18.	(c)	19.	(a)	20.	(a)
21.	(b)	22.	(a)	23.	(b)	24.	(d)	25.	(a)
26.	(c)	27.	(c)	28.	(b)	29.	(b)	30.	(b)
31.	(c)	32.	(c)	33.	(d)	34.	(b)	35.	(a)
36.	(c)	37.	(c)	38.	(b)	39.	(a)	40.	(c)
41.	(a)	42.	(d)	43.	(c)	44.	(c)	45.	(b)
46.	(c)	47.	(a)	48.	(b)	49.	(d)	50.	(c)
51.	(b)	52.	(b)	53.	(b)	54.	(a)	55.	(b)
56.	(a)	57.	(a)	58.	(c)	59.	(b)	60.	(a)
61.	(b)	62.	(c)	63.	(a)	64.	(a)	65.	(d)
66.	(c)	67.	(a)	68.	(d)	69.	(b)	70.	(c)
71.	(b)	72.	(d)	73.	(d)	74.	(c)	75.	(d)
76.	(a)	77.	(c)	78.	(a)	79.	(c)	80.	(b)
81.	(a)	82.	(a)	83.	(b)	84.	(a)	85.	(b)
86.	(b)	87.	(a)	88.	(b)	89.	(c)	90.	(c)
91.	(d)	92.	(c)	93.	(d)	94.	(a)	95.	(a)
96.	(d)	97.	(b)	98.	(c)	99.	(c)	100.	(b)
101.	(b)	102.	(d)	103.	(a)	104.	(b)	105.	(c)
106.	(c)	107.	(b)	108.	(b)	109.	(a)	110.	(c)
111.	(d)	112.	(b)	113.	(b)	114.	(a)	115.	(c)
116.	(b)	117.	(c)	118.	(a)	119.	(b)	120.	(b)
121.	(b)	122.	(d)	123.	(a)	124.	(b)	125.	(a)
126.	(a)	127.	(a)	128.	(c)	129.	(b)	130.	(b)
131.	(b)	132.	(a)	133.	(b)	134.	(a)	135.	(b)
136.	(b)	137.	(c)	138.	(b)	139.	(d)	140.	(b)
141.	(b)	142.	(d)	143.	(d)	144.	(c)	145.	(a)
146.	(a)	147.	(c)	148.	(d)	149.	(b)	150.	(c)
151.	(b)	152.	(c)	153.	(b)	154.	(a)	155.	(c)
156.	(b)	157.	(a)	158.	(d)	159.	(d)	160.	(d)
161.	(b)	162.	(d)	163.	(d)	164.	(d)	165.	(b)
166.	(c)	167.	(c)	168.	(c)	169.	(c)	170.	(c)
171.	(b)	172.	(c)	173.	(c)	174.	(c)	175.	(b)
176.	(b)	177.	(b)	178.	(c)	179.	(d)	180.	(d)
181.	(b)	182.	(c)	183.	(d)	184.	(a)	185.	(a)
186.	(b)	187.	(d)	188.	(c)	189.	(b)	190.	(c)
191.	(d)	192.	(c)	193.	(d)	194.	(d)	195.	(b)
196.	(a)	197.	(a)	198.	(c)	199.	(b)	200.	(a)

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Canadian Olympiad Problems

SECTION - A

Multiple Choice Questions with one correct answer

1. You are standing upright in a room in front of a vertical mirror. In this mirror, you can see from your position only the upper two-thirds of your body. You wish to see the entire length of your body reflected in the mirror. Which combination of the following three courses of action will achieve this?

(I) Move away from the mirror

(II) Move toward the the mirror

(III) Use a mirror whose height will allow you to see your whole image when you are at your initial position.

(a) (I) only (b) (II) only

(c) (III) only (d) either (I) or (III).

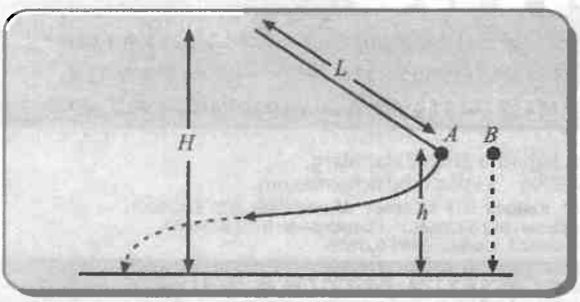
2. A 5 kg cart collides on a horizontal surface with a 20 kg cart. Which cart experiences the smaller force because of the collision?

(a) The 5 kg cart (b) The forces are equal

(c) The 20 kg cart

(d) It depends if the collision is elastic.

3. Two monkeys with the same mass stand on a branch at height h above the horizontal jungle floor. Monkey A steps off the branch holding the end of an inextensible rope of length L whose other end is tied to another branch at height H, lets go at the bottom of the swing, and falls freely to the floor, as shown below. Monkey B steps off and falls straight downward. Then, neglecting air resistance but not the tension in the rope, the total work W done on each monkey and the speed v with which each hits the floor are as follows



(a) $W_A < W_B$, $v_A < v_B$ (b) $W_A = W_B$, $v_A < v_B$

(c) $W_A = W_B$, $v_A = v_B$ (d) $W_A < W_B$, $v_A = v_B$.

4. A person, standing on a train that is accelerating forward at 3.3 m/s², throws a ball vertically upward. Neglecting air resistance, the magnitude of the ball's acceleration relative to the train is

(a) 9.8 m/s² (b) 10.3 m/s²

(c) 7.0 m/s² (d) 13.1 m/s².

5. I must cross a river in the shortest possible time. Water flows downstream at a constant 5.0 m/s between the two parallel shores. Taking the direction of the flow as reference, if my boat has a maximum speed of 10 m/s, it should head at

(a) 90° (b) 120°

(c) 150° (d) 27°.

6. A hoop and a solid cylinder have the same mass and radius. They both roll, without slipping, on a horizontal surface. If their kinetic energies are equal,

(a) the hoop has a greater translational speed than the cylinder

(b) the cylinder has a greater translational speed than the hoop

(c) the hoop and the cylinder have the same translational speed

(d) the hoop has a greater rotational speed than the cylinder.

7. A string clamped at both ends is vibrating. At the moment the string looks flat, the instantaneous transverse velocity of points along the string, excluding its end-points, must be

(a) zero everywhere

(b) dependent on the location along the string

(c) not zero anywhere

(d) non-zero and in the same direction everywhere.

8. In vacuum, a potential difference V is maintained between points a distance d apart. The corresponding electric field E accelerates an electron from rest to a speed v over that distance. Which one of the following statements is true?

(a) E does not depend on d
(b) E depends on V, not on d
(c) E depends only on d
(d) v depends on V, not on d.

9. Students claim that in a lab experiment they witnessed a headon elastic collision between two balls on a horizontal surface which resulted in the balls being both at rest. No external horizontal force was acting at any time on the masses. Which of these comments is the most appropriate about this process?
(a) initial speeds and masses must have been different
(b) initial speeds and masses must have been identical
(c) initial speeds, but not necessarily masses, were identical
(d) the process cannot have occurred as claimed.

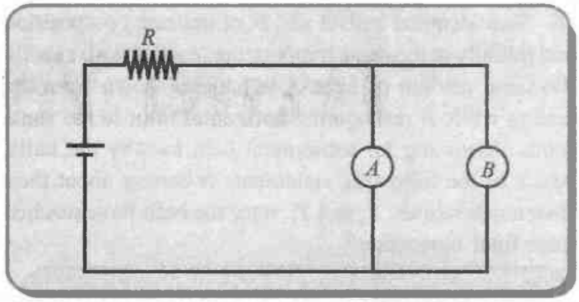
10. The potential across a 3 μF capacitor is 12V when it is not connected to anything. It is then connected in parallel with an uncharged 6μF capacitor. At equilibrium, the charge q on the 3μF capacitor and the potential difference V across it are
(a) q = 12 μC, V = 4 V (b) q = 24 μC, V = 8 V
(c) q = 36 μC, V = 12 V (d) q = 12 μC, V = 6 V.

11. In subatomic physics, one often associates a characteristic wavelength λ with a particle of mass m. If $\hbar = h/2\pi$ (h being Planck's constant) and c the speed of light, which of the following expressions is most likely to be the correct one?
(a) $\lambda = \hbar c/m$ (b) $\lambda = \hbar/mc^2$
(c) $\lambda - \hbar m/c$ (d) $\lambda = \hbar/mc$.

12. At equilibrium, the electric field at a point on a closed conducting surface, whether the surface is charged or neutral, can never be
(a) tangent to the surface
(b) perpendicular to the surface
(c) zero
(d) directed inward since it must vanish inside.

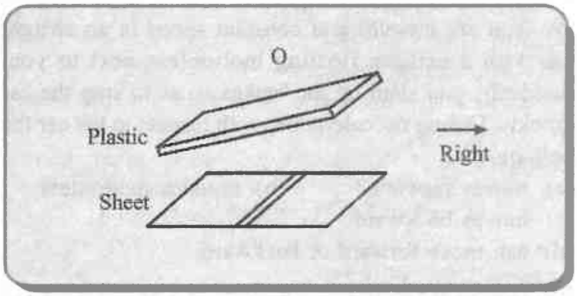
13. A uniform cubical box of mass M rests on a horizontal floor with one edge against a small obstruction fixed to the floor. Can a horizontal force of magnitude F applied on the box at the centre of the side opposite the obstruction tip the box?
(a) No, never (b) yes, only if $F > mg$
(c) yes, $F > mg/2$ is sufficient
(d) yes, only if $F > 2mg$.

14. A circuit consists of a battery, a resistor R, and two light bulbs A and B as shown below



If the filament in lightbulb A burns out, then the following is true for light bulb B
(a) it is turned off
(b) its brightness does not change
(c) it gets dimmer
(d) it gets brighter.

15. An observer at O views two closely spaced lines on the bottom sheet through an angled slab of plastic with parallel faces, exactly as shown in the figure below.

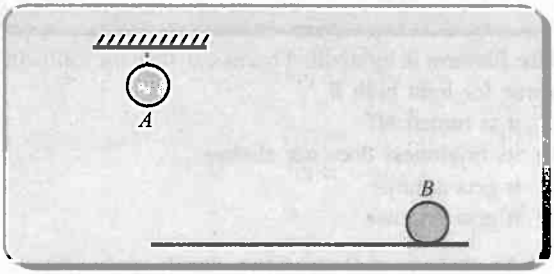


Compared to when there is no plastic, the lines appear to the observer
(a) the same but shifted to the right
(b) shifted to the left and spaced further apart
(c) shifted to the right and spaced closer together
(d) exactly as they do without the plastic slab.

16. If all of Earth's polar ice were suddenly to melt into the oceans, in the short term the length of the day would
(a) increase (b) remain the same
(c) decrease
(d) first decrease, then increase.

17. Two uncharged balls A and B, each very light and coated with a conducting material, hang vertically side by side just touching each other. A positively-charged glass rod is brought near ball A without touching it. Now A and B are separated and then the glass rod is removed. If Q_A and Q_B represent the electric charges on A and B, respectively, you conclude that
(a) $Q_A < 0$ and $Q_B < 0$ (b) $Q_A < 0$ and $Q_B > 0$
(c) $Q_A > 0$ and $O_B < 0$ (d) $Q_A > 0$ and $Q_B > 0$.

18. Two identical balls A and B, of uniform composition and initially at the same temperature, each absorb exactly the same amount of heat. A is hanging down from the ceiling while B rests on the horizontal floor in the same room. Assuming no subsequent heat loss by the balls, which of the following statements is correct about their final temperatures, T_A and T_B, once the balls have reached their final dimension?



(a) $T_A < T_B$ (b) $T_A > T_B$
(c) $T_A = T_B$ (d) $T_A < T_B$.

19. You are travelling at constant speed in an airtight car with a balloon floating motionless next to you. Suddenly, you slam on the brakes so as to stop the car quickly. During decceleration, with respect to the car the balloon

(a) moves forward (b) remains motionless
(c) moves backward
(d) can move forward or backward.

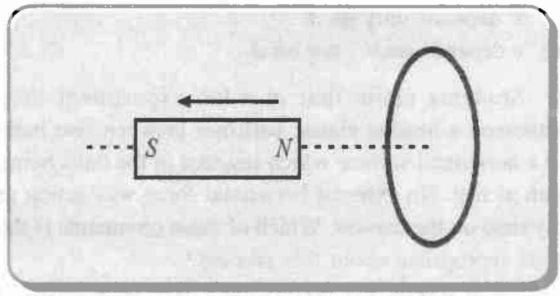
20. Due to tidal friction on earth, the radius R of the Moon's orbit is increasing at the rate of a few centimetres per year. During this process, the moon's angular momentum

(a) remains constant since its speed decreases
(b) remains constant but its total energy increases
(c) increases as $\sqrt{R}$ while its total energy increases
(d) decreases as $\sqrt{R}$ while its kinetic energy decreases.

21. In order to measure the speed v of blood flowing through an artery, a uniform magnetic field B is applied in a direction perpendicular to the flow and a voltmeter measures the voltage across the diameter D of the artery, at right angles to B. If positive and negative ions in the blood are longitudinally at rest with respect to the flow, the speed of the flow is closest to

(a) $v = V/BD$ (b) $v = BD/V$
(c) $v = VD/B$ (d) $v = B/VD$.

22. A bar magnet with its north (N) and south (S) poles as shown below is initially moving to the left, along the axis of, and away from a circular conducting loop. A current I is induced in the loop, with a the acceleration of the magnet due to this current. As seen from the magnet looking in the direction of the loop,



(a) I runs clockwise and a points to the left
(b) I runs counterclockwise and a points to the right
(c) I runs clockwise and a points to the right
(d) I runs counterclockwise and a points to the left.

23. You are moving a negative charge $q < 0$ at a small constant speed away from a conducting spherical shell on which resides a negative charge $Q < 0$. The electrostatic field of Q is $\vec{E}$. Let U be the total energy of q, W_a the work done by the force $\vec{F_a}$ you exert on q, and W_E the work done by the electrostatic force $\vec{F_E}$ on q. Then, as q is being moved,

(a) $W_a = -W_E$, and therefore U remains constant
(b) $\vec{F_a} = -\vec{F_E}$, and therefore U remains constant
(c) U increases (d) U decreases.

24. An ice cube of pure fresh water floats on pure fresh water in a glass. A huge ice shelf, also of pure fresh water, floats on the ocean away from Antarctica. Neglecting the contribution due to the density of air, as the ice cube and the iceberg melt,

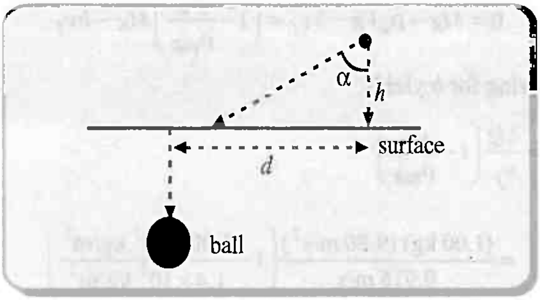
(a) the water level rises both in the glass and in the ocean
(b) the water level does not change in either case
(c) the water level stays the same in the glass but rises in the ocean
(d) the water level decreases in the glass but stays the same in the ocean.

SECTION - B

Long Answer Questions

25. A uniform ball of mass $M = 1.00$ kg is released from rest at the surface of a pond and sinks vertically into the water. An observer, wishing to determine the density of this ball, measures the time-dependence of the angle α between the vertical at his position, a distance h above the surface, and the direction of the ball's apparent instantaneous position (see figure). The horizontal distance between the observer and the initial position of

the ball is d.



The drag force acting on the ball as it sinks is well approximated at low speed v by $F_{drag} = -bv$, where b is a constant. We also take the density of water to be $\rho_w = 1000$ kg/m³ and its refraction index as $n_w = 1.33$.

(a) Derive an expression for the instantaneous depth y of the ball as a function of α, h, and d.

(b) Having calculated the depth of the ball as a function of time, the observer can then construct the following table for the speed of the ball as a function of time:

Time [s]	Speed [m/s]	Time [s]	Speed [m/s]
0.000	0.000	0.225	0.8425
0.010	0.0910	0.275	0.8767
0.025	0.2086	0.325	0.8966
0.075	0.5081	0.375	0.9082
0.125	0.6823	0.425	0.9145
0.175	0.7836	0.475	0.9155

From these data, find the initial acceleration of the ball and estimate at which value its speed will stabilise. Then calculate the density of the ball and obtain a value for the drag coefficient b.

26. Bicycle headlights are often powered by a generator, with the rim of the generator's shaft rolling against the tire's rim due to the rotation of the wheel. The shaft is rigidly connected to a coil within the generator which rotates in a magnetic field B.

In one such generator, the coil has 125 turns of wire and a cross-sectional area of 0.0010 m², immersed in a field of magnitude 0.080 T. At the area of contact with the tire, the rim of the generator's shaft has a radius of 1.25 cm. The tire's diameter is 66 cm.

(a) If the lightbulb in the headlight needs 5.0W of average electrical power, corresponding to a voltage amplitude of 4.0V, to produce a decent amount of light, calculate the linear speed of the bicycle needed, assuming no slipping anywhere in the problem.

(b) Calculate the torque that must be supplied by the bicycle wheel to produce the required average electrical power for the bulb. State briefly two other simplifying assumptions that must be made.

(c) What is the amplitude of the current induced in the coil under these conditions?

(d) To the extent that the lightbulb obeys Ohm's Law, and that its resistance is constant, by what factor would the power delivered to the bulb increase if the cyclist tripled the bicycle's speed (presumably downhill or at the Tour de France)?

27. The long jump as an Olympic sport dates back at least as far as 700 BC. Unlike in the modern Olympics, it was practised not only from a running start, but also from a standing start. The length of a jump was measured (as it still is) from the point where the back of the feet touched the ground on landing. Paintings on ancient Greek vases depict athletes jumping from a standing start while holding compact weights in both hands. Examples of these have been dug up by archaeologists, and typical ones, made of stone or lead, each have a mass of around 3 kg.

(a) Write a short paragraph explaining qualitatively how athletes could boost their performance, ie. jump further from a standing start, by carrying such weights. More precisely, describe what they would have done with the weights during the jump. You can accept that, as biomechanics research has shown, a loaded body could take off at the same speed and angle as an unloaded one.

(b) Estimate by how much the length of a 3 m jump could be increased for a 65 kg athlete jumping at an angle of 50°. Remember that this takes place from a standing start, not a running start like today's long jump. You can take the centre of mass of the body to be at a height of 1m above ground and the length of the arms to be 65 cm. Also, at the moment of take-off, the athlete is leaning forward so that his shoulders are about 15 cm in front of the centre of mass of his body.

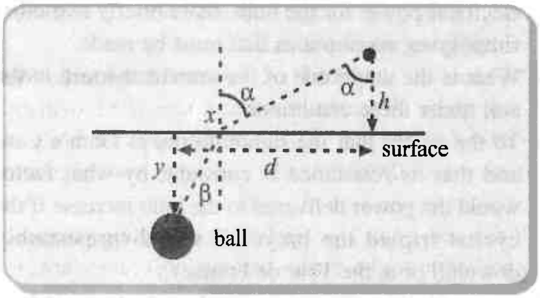
SOLUTIONS

SECTION A

1. (c)	2. (b)	3. (c)	4. (b)	5. (a)
6. (b)	7. (b)	8. (d)	9. (d)	10. (a)
11. (d)	12. (a)	13. (b)	14. (d)	15. (b)
16. (a)	17. (b)	18. (b)	19. (c)	20. (c)
21. (a)	22. (c)	23. (d)	24. (c)	

SECTION B

25.



(a) Let x be the horizontal distance from the point where the ball was released, to the point where a ray originating from the instantaneous position of the ball at depth y crosses the surface to reach the observer.

From Snell's law we have $\sin\alpha = n_w \sin\beta$, where $n_w = 1.33$ is the index of refraction of water.

From geometry, we can also write :

$$x = d - h\tan\alpha$$

$$\tan\beta = x/y$$

Then $y = \dfrac{x}{\tan\beta} = x\dfrac{\cos\beta}{\sin\beta} = x\sqrt{\dfrac{1-\sin^2\beta}{\sin^2\beta}}$

$$= (d - h\tan\alpha)\sqrt{\left(\frac{n_w}{\sin\alpha}\right)^2 - 1}$$

(b) The initial acceleration a_0 can be calculated from the first velocity point in the data table. Velocity changed from 0 to 0.091 m/s in 0.01s, which gives $a_0 = 9.10\ \text{m/s}^2$.

The terminal speed can be read off the table as approximately $v_f = 0.916\ \text{m/s}^2$.

The total instantaneous downward force F acting on the ball when it has speed v is

$$F = Mg - \rho_w Vg - bv \qquad \text{...(i)}$$

where Mg is the gravitational force, $\rho_w Vg$ is the upward buoyancy force if the ball has volume V, and bv is the drag force. By Newton's second law, $F = Ma$, where a is the acceleration of the ball.

Initially, v is small enough that the drag force can be ignored, and we can write

$$F = \rho_{ball}Vg - \rho_w Vg = \rho_{ball}Va_0$$

with ρ_{ball} the density of the ball. Thus,

$$\rho_{ball} = \frac{\rho_w}{1 - a_0/g}$$

$$= \frac{1000\ \text{kg/m}^3}{1 - 9.10/9.80} = 1.4 \times 10^4\ \text{kg/m}^3$$

On the other hand, when the speed has reached its final value v_f, the acceleration vanishes and eq. (i) becomes

$$0 = Mg - \rho_w Vg - bv_f = \left(1 - \frac{\rho_w}{\rho_{ball}}\right)Mg - bv_f$$

Solving for b yields

$$b = \frac{Mg}{v_f}\left(1 - \frac{\rho_w}{\rho_{ball}}\right)$$

$$= \frac{(1.00\ \text{kg})\,(9.80\ \text{m/s}^2)}{0.916\ \text{m/s}}\left(1 - \frac{1.00\times10^3\ \text{kg/m}^3}{1.4\times10^4\ \text{kg/m}^3}\right)$$

$$= 9.9\ \text{kg/s}$$

26. (a) Since the generator shaft contacts the tire very close to its edge, we can take its tangential speed v to be that of the bicycle wheel, and therefore the linear speed of the bicycle itself. This is related to its rotational speed ω by $v = \omega r$, where r is the radius of the shaft.

As is readily derived from Faraday's law applied to the rotating coil with N turns and area A, immersed in a uniform magnetic field with magnitude B, the voltage output of the generator as a function of time is

$$\varepsilon = \omega NBA \sin\omega t$$

and its amplitude is therefore $\varepsilon_{max} = \omega NBA$. Combining these expressions leads to

$$v = \frac{r\varepsilon}{NBA}$$

$$= \frac{(1.25\times10^{-2}\ \text{m})(4.0\text{V})}{(125)(0.080\ \text{T})(1.0\times10^{-3}\text{m}^2)} = 5.0\ \text{m/s}$$

(b) The average torque supplied by the tire's rotation is given by $\tau = P/\omega$, with P the average mechanical power. If we ignore any loss due to (i) friction and (ii) the resistance of the coil, P is also the average electrical power produced by the generator. Then

$$\tau = rP/v$$

$$= \frac{(1.25\times10^{-2}\ \text{m})(5.0\ \text{W})}{5.0\ \text{m/s}}$$

$$= 1.25\times10^{-2}\ \text{N·m}$$

(c) The power amplitude P_{max} is twice the average power, and the maximum current is therefore

$$I_{max} = P_{max}/\varepsilon_{max} = (10\ \text{W})/(4.0\ \text{V}) = 2.5\ \text{A}$$

(d) Assuming that the light bulb obeys Ohm's Law, the power it consumes goes like the square of the voltage supplied at constant resistance. Since that voltage goes like the linear speed of the bicycle, power is proportional to v^2. If that speed triples (to 15 m/s, or 54 km/hr), the power supplied is multiplied by 9. The bulb may well burn out!

27. (a) The centre of mass of the body of the athlete loaded

with the weights follows a parabolic trajectory. Then, if the jumper thrusts the weights forward at arm's length as he jumps, the centre of mass lies a bit forward and higher from its position than if there were no weights. In midflight, the athlete then swings the weights down and back-ward before landing, which puts the point of contact of his feet at a position slightly further ahead with respect to the centre of mass then if no weights were carried. There is also an extra enhancement coming from the upward vertical motion of the body with respect to the centre of the mass as the weights are swung down before landing, in effect extending its trajectory a bit further forward.

(b) Let M be the mass of the body and m the total mass of the weights. The position of the centre of mass is given by $R = (X, Y)$:

$$R = \frac{Mr_1 + mr_2}{M+m} = \frac{r_1 + \frac{m}{M}r_2}{1 + m/M}$$

where r_1 and r_2 are the positions of the centre of mass of the body and the centre of mass of the weights, respectively. The initial shift in the position of the centre of mass of the body due to the weights is then

$$\Delta R = \frac{Mr_1 + mr_2}{M+m} - r_1 = \frac{\Delta r}{1 + M/m}$$

where $\Delta r = (\Delta x, \Delta y) = r_2 - r_1$. With $M = 65$ kg and $m = 6$ kg, this gives $\Delta R = 0.085\ \Delta r$.

Let us break down the effect into three parts, two horizontal ones and one vertical.

- At take-off, the weights are held at arm's length (arms horizontal). Assuming 65 cm as the length of the arms, plus another 15 cm for the horizontal position of the shoulders relative to the centre of mass of the body leaning forward, we have $\Delta x = x_2 - x_1 = 80$ cm, which gives $\Delta X = 6.8$ cm.
- At landing, the arms are swung backwards. We assume that then arms make an angle of 40° with the vertical. Then the centre of mass of the body is 0.0845 sin 40°(60 cm) = 3.3 cm ahead of the centre of mass of the system.
- If the athlete always lands in a crouching position, whether or not he carries weights, it is reasonable to assume that the vertical position of the weights has shifted by up to one metre between take-off and landing. Therefore, when the trajectory of the system's centre of mass is at the vertical position it would have at landing withtout weights, the centre of mass of the body is higher by about $\Delta Y = 0.085 \times 1\text{m} = 8.5$ cm. The angle of the trajectory being about 50°, the corresponding horizontal extension of the length of the jump is $\Delta X = \Delta Y/\tan 50° = 7.1$ cm.

Totalling these three contributions gives an extension of the jump's length of about 17 cm. This is of course quite dependent on the assumptions we made, but gives a reasonable estimate.

Note : Athletes were not allowed to throw the weights while in flight, which makes sense as the long jump was not meant as a weight-throwing contest on top of the jump itself. ❖

Thought Provoking Problems in OPTICS

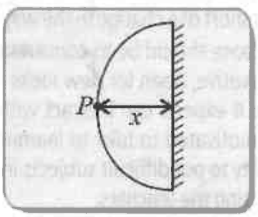
By : **Prof. Rajinder Singh Randhawa**

1. In YDSE, the incident light is composed of two wavelengths 6696 Å, and 6699Å. The screen is placed 3 m away and the distance between the slits is 10^{-3} m. (a) Find the order upto which fringes can be seen on the screen? (b) And how far from the centre of the screen does this occur?

2. Suppose that one of the slits in a YDSE is wider than the other, so the amplitude of the light reaching the central part of the screen from one slit is thrice that from the other slit. Find an expression for the light intensity I at the screen as a function of θ, the angular position.

3. A small coin is placed at the bottom of a cylindrical vessel of radius R and height h. If a transparent liquid of refractive index μ completely filled into the cylinder, find the minimum fraction of the area that should be covered in order not to see the coin.

4. A spherical surface of radius of curvature R enclosing a medium of refractive index $\mu = 1.5$. Find the distance x where a mirror should be present so that the image of a distant point object lying on the principal axis is formed at the pole P.



5. Due to a vertical temperature gradient in the atmosphere the index of refraction varies as $\mu = \mu_0\sqrt{1+ay}$, where μ_0 is the index of refraction at the surface and $a = 8 \times 10^{-6}$ m^{-1}. A person of height $h = 2$ m stands on a level surface. Beyond what distance he cannot see the runway?

6. A vertical beam of cross-sectional radius r is incident symmetrically on the curved surface of a glass hemisphere $\left(\mu = \frac{3}{2}\right)$ of radius $2r$ placed with its base on a horizontal table. Find the radius of the luminous spot formed on the table.

7. Light is incident at an angle θ on one plane end of a transparent cylindrical rod of refractive index μ. Determine the least value of μ so that the light entering the rod does not come out of the curved surface of the rod irrespective of the value of θ.

8. A thin glass sheet ($\mu = 1.52$) is introduced normally in the path of one of the two interfering waves. The central bright fringe is observed to shift to the position originally occupied by the fifth bright fringe. If $\lambda = 5890$ Å find the thickness of the glass sheet.

SOLUTIONS

1. (a) The fringes will be invisible when n^{th} maximum of wavelength 6699 Å coincides with the $\left(n+\frac{1}{2}\right)$ minimum of wavelength 6696 Å. Hence $n\lambda = \left(n+\frac{1}{2}\right)\lambda'$

$$n\,(6699) = \left(n+\frac{1}{2}\right)6696$$

$$n = 1116$$

So, the fringes will be visible to the order 1116

(b) Distance from the centre is given by

$$x = \frac{n\lambda D}{d} = \frac{1116 \times 6699 \times 10^{-10} \times 3}{10^{-3}} = 2.25 \text{ m}$$

2. The resultant intensity at a point is

$$I = K\,(A_1^2 + A_2^2 + 2A_1A_2\cos\phi) \quad \text{...(1)}$$

As $A_1 = 3A_2 = 3A$

$\therefore$ The intensity at the central position

$$I_0 = K(3A + A)^2 = 16\,KA^2 \text{ or } K = \frac{I_0}{16A^2} \quad \text{...(2)}$$

The path difference at any point P is $\Delta x = d\sin\theta$

The phase difference at any point P is $\phi = \frac{2\pi}{\lambda} \times \Delta x$;

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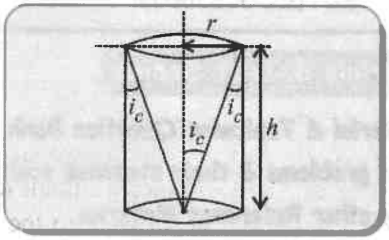
$$\phi = \frac{2\pi}{\lambda}(d\sin\theta) \qquad ...(3)$$

Thus, equation (1) becomes,

$$I = \frac{I_0}{16A^2}\left[(3A)^2 + A^2 + 2.(3A).A\cos\left(\frac{2\pi d\sin\theta}{\lambda}\right)\right]$$

$$\therefore \quad I = \frac{I_0}{16}\left[10 + 6\cos^2\frac{2\pi d\sin\theta}{\lambda}\right]$$

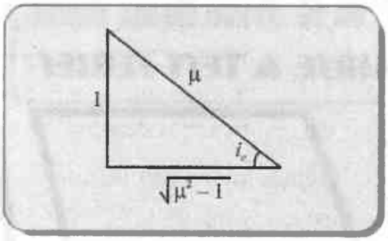
3. When the rays coming from the coin incident at an angle $i > i_c$, they will be totally reflected.



$\therefore$ Minimum area that should be covered, $A = \pi r^2$.

As $\tan i_c = \dfrac{r}{h} \Rightarrow r = h\tan i_c$

Since $\sin i_c = \dfrac{\mu_a}{\mu} = \dfrac{1}{\mu} \Rightarrow \tan i_c = \dfrac{1}{\sqrt{\mu^2 - 1}}$



$\therefore \quad r = \dfrac{h}{\sqrt{\mu^2 - 1}} \quad \therefore A = \pi r^2 = \dfrac{\pi h^2}{\mu^2 - 1}$

The total area of the base $A' = \pi R^2$

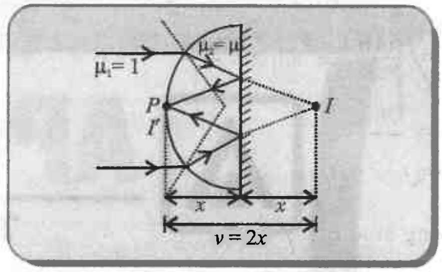
$\Rightarrow$ The fraction of base area covered $= \dfrac{\left(\dfrac{\pi h^2}{\mu^2 - 1}\right)}{\pi R^2}$

$$= \frac{h^2}{(\mu^2 - 1)R^2}$$

4. Since light comes from very distant object i.e. $u = \infty$

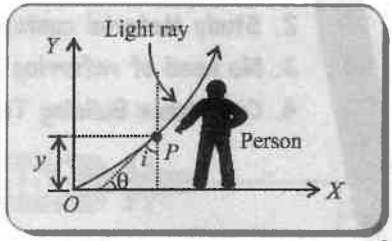
$$\Rightarrow \frac{\mu}{v} - \frac{1}{\infty} = \frac{\mu - 1}{R}$$

$$\Rightarrow v = \frac{\mu R}{\mu - 1} = \frac{1.5R}{1.5 - 1} = 3R$$



Due to presence of the plane mirror, the image formed at I behaves as a virtual object for the plane mirror and a real image I' is formed in front of the plane mirror, at the pole P. $\Rightarrow x + x = v \Rightarrow x = \dfrac{v}{2} = \dfrac{3R}{2}$

5. Let O be the object visible to man and P be a point on the trajectory of the ray $\theta = 90 - i$.



The slope of tangent at point P is $\tan\theta = \dfrac{dy}{dx} = \cot i$

Using Snell's law,

$$\mu_0 \sin 90° = \mu \sin i = \left(\mu_0\sqrt{1 + ay}\right)\sin i$$

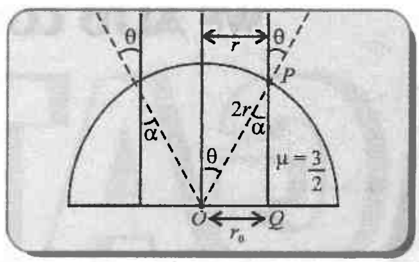
$$\sin i = \frac{1}{\sqrt{1 + ay}}, \ \cot i = \frac{dy}{dx} = \sqrt{ay}$$

$$\therefore \int_0^y \frac{dy}{\sqrt{ay}} = \int_0^x dx; \quad \therefore x = 2\sqrt{\frac{y}{a}} = 2\sqrt{\frac{2}{8\times10^{-6}}}$$

$x_{max} = 1000$ m

6. Let θ = angle of incidence

α = angle of refraction



For the extreme rays,

$$\sin\theta = \frac{r}{2r} = \frac{1}{2} \Rightarrow \cos\theta = \frac{\sqrt{3}}{2}$$

As $\mu = \dfrac{\sin\theta}{\sin\alpha} \Rightarrow \sin\alpha = \dfrac{\sin\theta}{\mu} = \dfrac{1}{2}\times\dfrac{2}{3} = \dfrac{1}{3}$ and

$\cos\alpha = \dfrac{\sqrt{8}}{3}$

In ΔOPQ, $\angle OQP = 90 + \theta - \alpha$.

Applying sine rule; $\dfrac{2r}{\sin(90+\theta-\alpha)} = \dfrac{r_0}{\sin\alpha}$

$\therefore\ r_0 = \dfrac{\sin\alpha}{\cos(\theta-\alpha)}.2r = \left(\dfrac{\sin\alpha}{\cos\theta\cos\alpha + \sin\theta\sin\alpha}\right).2r$

Using above values

$r_0 = 0.678r$

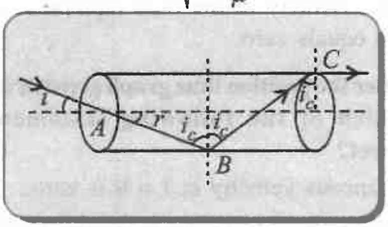
7. As $i_c = \sin^{-1}\left(\dfrac{1}{\mu}\right)$ at B

Snell's law for refraction at A yields

$$\frac{\sin i}{\sin r} = \mu \Rightarrow \sin r = \frac{\sin i}{\mu} \qquad ...(1)$$

Since $r + i_c = 90^\circ \Rightarrow \sin(90 - i_c) = \cos i_c$. For a ray not to come through the curved surface, $r < 90 - i_c$

$$\Rightarrow \sin r < \sqrt{1-\sin^2 i_c} < \sqrt{1-\frac{1}{\mu^2}} \qquad ...(2)$$



Eliminating $\sin r$ from (1) and (2), we get

$$\frac{\sin i}{\mu} \le \sqrt{1-\frac{1}{\mu^2}}$$

$$\Rightarrow \sin i < \sqrt{\mu^2 - 1}$$

$$\mu^2 - 1 > \sin i \ ; \ \sin i \le \sqrt{\mu^2-1}$$

$$\mu > \sqrt{1+\sin\theta}$$

$\Rightarrow \mu_{min} = \sqrt{2}$ Since $\sin\theta < 1$,

8. x_0 = displacement of images = 5β

$$\therefore\ \frac{D}{d}(\mu-1)t = 5\times\frac{\lambda D}{d}$$

$$t = \frac{5\lambda}{\mu-1} = \frac{5\times 5890\times 10^{-8}}{1.52-1} = 5.66\times 10^{-4}\text{ cm}$$

❖

AIEEE, IIT-JEE or PMT
You Can Meet The Challenges

When one looks at the question papers for the past many years, one thing is clear. The general standard is rising.

For IIT, one has to not only know the concepts thoroughly but must have also the ability to calculate fast the applications which are dependent on many concepts for the same problem.

In fact, for the purpose of studying physics, chemistry, mathematics whether one goes for any exam or not, the most important things are the concepts in each chapter. If the basic concepts are clear and the student develops the attitude to think, to ask why, and seek the answers to the logical limit, there is no need to fear any exam here or in the universities. IIT-JEE or AIEEE or PMT, in fact any exam can be tackled if the concepts are clear.

Of course speed and accuracy should be the key-word for success. Speed comes with practice.

To learn to go straight to the heart of the problem, reducing the given problem to elementary ones is all that is needed. Practice and practice as if the winning of the test matches depends on you.

Think, think straight, and go to the roots of the problem when studying, then REVISE, REVISE. This is the key for success. Revise immediately after you have learnt something; revise again and again till you know your subject like the palm of your hand.

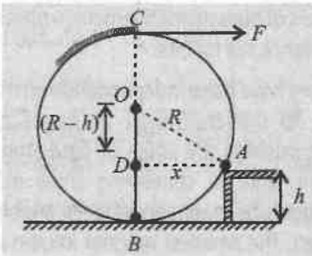
One does not learn 50% truth for passing, 60% truth for getting the cut-off percentage and reserve 100% learning for the rest. Either one works for 100% or one does not work. What you get is not in your hands. But you work for is in your hands. Revise everything from class XI onwards. Do not leave anything or play Monte Carlo. **You can win anything if you have the will to do it. Trust in God and buckup.**

Editor

Thought Provoking Problems in Rotational motion

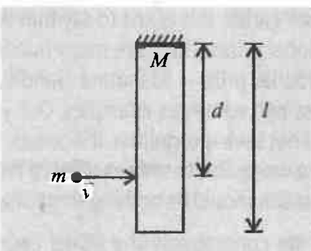
By : **Prof. Rajinder Singh Randhawa***

1. A cylinder of weight W and radius R is to be raised on to a horizontal step of height h as shown in figure. A rope is wrapped around the cylinder and pulled horizontally. Find the minimum force F necessary to raise the cylinder and the reaction force at A assuming the cylinder does not slip.



2. A ladder rests on the floor, leaning against a wall of coefficient of static friction between the ladder and floor is μ_1 and that between ladder and wall is μ_2, What is the minimum angle 0 that ladder can make with the floor if the ladder is not to slip? (Assuming there is uniformly distributed mass).

3. A rod of mass M and length l is pivoted at the top. A body of mass m and velocity v hits at distance d from the top and stick to it. Find the ratio of initial energy to the final energy.



4. A spherical ball of mass m and radius r is projected along a rough horizontal surface so that initially ($t = 0$) it slides with linear speed u but does not rotate. As it slides, it begins to spin and eventually rolls without slipping. How long does it take to begin rolling without slipping?

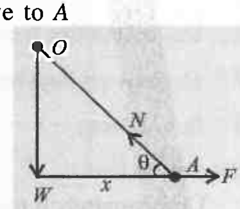
5. A spherical ball of mass m and radius r moving with velocity u strikes elastically a rigid surface at an angle α to the normal. Assuming that slipping occurs while the sphere is in contact with the surface and coefficient of friction is μ. Find (μ) coefficient of friction in terms of α and β when the ball is reflected at an angle β to the normal.

SOLUTIONS

1. The moment of arm x of the weight relative to the point A, $x = \sqrt{R^2 - (R-h)^2} = \sqrt{2Rh - h^2}$

The moment arm of F relative to A

$CD = 2R - h$



The net torque about A is

$Wx - F.\ (2R - h) = 0$

$\therefore \quad W = \sqrt{2Rh - h^2} - F.(2R - h) = 0$

$$\Rightarrow F = \frac{W\sqrt{2Rh - h^2}}{2R - h}$$

Now,

Using condition of equilibrium, $\left.\begin{matrix}\sum F_x = 0 \\ \sum F_y = 0\end{matrix}\right\}$

i.e. $N\cos\theta = F$ ...(i)

and $N \sin 0 = W$ ...(ii)

Dividing, (ii) by (i) we get

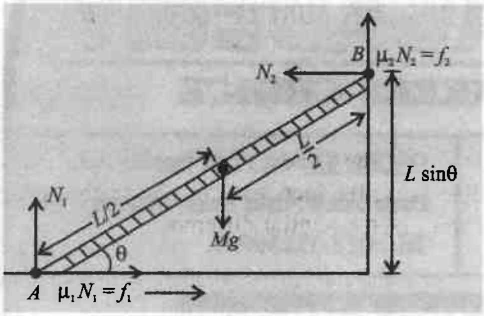
$$\tan\theta = \frac{W}{F}$$

Squaring and adding up (i) and (ii), we get $N = \sqrt{F^2 + W^2}$

2. For equilibrium, $\left.\begin{matrix}\sum F_x = 0 \\ \sum F_y = 0\end{matrix}\right|$

Randhawa Institute of Physics, S.C.O. 208, First Floor, Sector-36D, Chandigarh. Email : randhawainstitute_physics@yahoo.com

$\therefore \quad \Sigma F_x = \mu_1 N_1 - N_2 = 0$ ...(1)
and $\Sigma F_y = N_1 + \mu_1 N_2 - Mg = 0$ ...(2)
Now,
Taking moment about point 'A' is given by



(As $f_1 = \mu_1 N_1$ and $f_2 = \mu_2 N_2$)

$$f_2 (L\cos\theta) + f_1 (L\sin\theta) = Mg\left(\frac{L}{2}\cos\theta\right) \quad ...(3)$$

Solve (1), (2) and (3), we get $\theta = \tan^{-1}\left(\frac{1-\mu_1\mu_2}{2\mu_1}\right)$

3. Initial energy, $E_i = \frac{1}{2}mv^2$ ...(1)

Final energy, $E_f = \frac{L'^2}{2I'}$ ...(2)

About pivot, according to conservation of angular momentum,
$L' = L = mvd$ ...(3)

M. I. after collision, $I' = \frac{Ml^2}{3} + md^2$ ...(4)

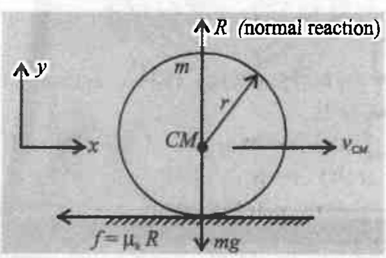
Using (3) and (4) in (2), we get

$$E_f = \frac{(L')^2}{2I'} = \frac{(mvd)^2}{2\left(\frac{Ml^2}{3}+md^2\right)} = \frac{3m^2v^2d^2}{2(Ml^2+3md^2)} \quad ...(5)$$

From eqns (1) and (5);

$$\frac{E_i}{E_f} = \frac{\frac{1}{2}mv^2 \times 2(Ml^2+3md^2)}{3m^2v^2d^2} = \frac{Ml^2+3md^2}{3md^2}$$

4. Eqns of motion for (translational) sphere are given by



$\Sigma F_x = -f = ma \Rightarrow -\mu_k R = ma$ ...(1)
$\Sigma F_y = R - mg = 0$ ...(2)
From eqns (1) and (2), $a = -\mu_k g$ ...(3)
Velocity of C.M. at time 't' is $v = u + at$
ie $v = u - \mu_k g t$ ...(4)

Eqn of motion for rotation is $\tau = \mu_k mgr = \frac{2}{5}mr^2\alpha$

$$\alpha = \frac{5}{2}\frac{\mu_k g}{r} \quad ...(5)$$

Then the angular velocity of the ball at time t is

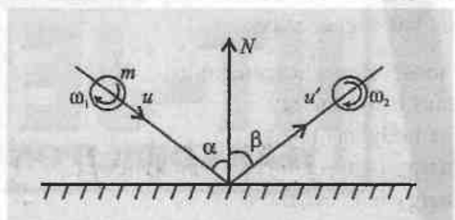
$$\omega = 0 + \alpha t = \frac{5\mu_k gt}{2r} \quad ...(6)$$

The condition for pure rolling ; $v_{cm} = \omega R$

$$\therefore \quad u - \mu_k g t_0 = \frac{5\mu_k g t_0 r}{2r}$$

$$t_0 = \frac{2u}{7\mu_k g}$$

5. Since collision is elastic, then $u\cos\alpha = u'\cos\beta$ ...(1)



From impulse momentum theorem ;
$N\Delta t = \Delta p = p_f - p_i = 2mu\cos\alpha$ ...(2)
Component of impulse parallel to the surface
$= \mu N\Delta t = 2mu\mu\cos\alpha$
Also,
$2mu\mu\cos\theta = mu'\sin\beta - mu\sin\alpha$ ...(3)

From (1) and (3), after solving ; $\mu = \frac{\tan\beta - \tan\alpha}{2}$

Now,
Angular impulse on the ball
$= (2mu\mu\cos\alpha)\, r$

$$\therefore \quad \Delta\omega = \frac{2umu\cos\alpha}{I} = \frac{2\mu mur\cos\alpha}{\frac{2}{5}mr^2}$$

$$\Delta\omega = \frac{5\mu u\cos\alpha}{r}$$

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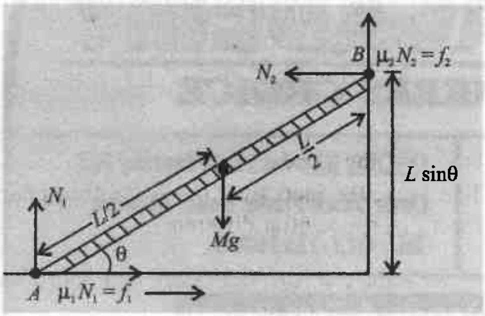

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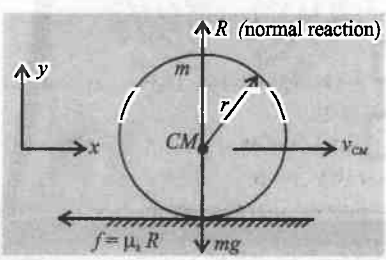

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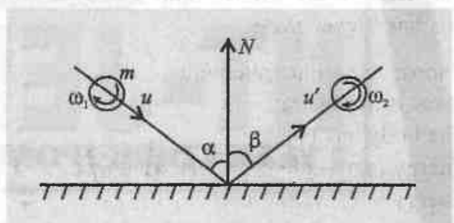

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$$\Delta\omega = \frac{5\mu u\cos\alpha}{r}$$

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SOLVED PAPER 2007

CBSE-PMT (Mains)

1.(a) Capacitance of 6 μF is charged by 6 V battery. Now it is connected with inductor of 5 mH. Find current in inductor when 1/3rd total energy is magnetic.

(b) An object is thrown vertically upward with some speed. It crosses 2 points p, q which are separated by h metre. If t_p is the time between p and highest point and coming back and t_q is the time between q and highest point and coming back, relate acceleration due to gravity t_p, t_q and h.

2.(a) Two coils m and n having 10 turns and 15 turns respectively are placed close to each other. When 2 A current is passing through coil m, then flux linked in coil n is 1.8×10^{-4} weber per turn. If 3 A current is passed through coil n then, calculate the flux linked per turn of coil m.

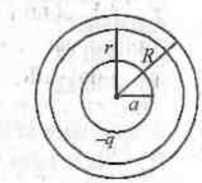
(b) A string having tension 360 N and mass / length $= 4 \times 10^{-3}$ kg/m. It produces two consecutive resonant frequencies with a tuning fork, which are 375 Hz and 450 Hz. Find mass of string.

3.(a) In photoelectric effect a photon of wavelength 3300 Å is incident on metal surface of work function 2.5 eV. Now emitted electrons enter in transverse magnetic field 6.7×10^{-6} T and turn in a circular path of radius 50 cm. Calculate charge of electron from the given data ?

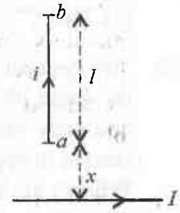
(b) If temperature and magnetic field applied across paramagnetic substance are tripled, how many times intensity of magnetization of substance will change ?

4.(a) Equation for two waves is given as $y_1 = a\sin(\omega t + \phi_1)$, $y_2 = a\sin(\omega t + \phi_2)$. If amplitude and time period of resultant wave does not change then calculate $(\phi_1 - \phi_2)$.

(b) A solid sphere of radius a having charge q^- is placed inside spherical shell of inner radius r, outer radius R. Find potential at distance x, where $r < x < R$.

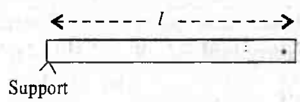


5.(a) Find the force on conductor carrying current i is shown in the figure.



(b) A conducting cone is given charge q. How will the charge density and electric potential varies at different points of cone ?

6.(a) A rod is hinged as shown in the figure, supported by a table. When the support is withdrawn calculate the acceleration of centre of mass.



(b) There are two wires each produces frequency of 500 Hz. By what percentage tension in one wire is increased so that 5 beats per second can be heard ?

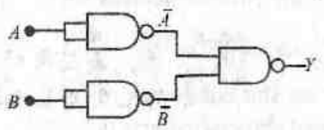
7.(a) Write the difference between nuclear force and Coulombian force.

(b) An aeroplane is moving horizontally with speed of 100 m/sec at height of 2000 m from ground. A small object is detached from it and strikes the ground. Calculate the angle from vertical with which it strikes the ground.

(c) Which of the following quantities have same dimensional formula? Angular momentum, impulse, energy, torque, force and moment of inertia.

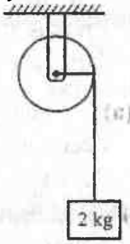
8.(a) Prove that for a monatomic gas ratio of specific heat $\gamma = 5/3$

(b) Give the truth table of the following



9.(a) When 4 ampere current flows through battery from positive to negative terminal potential difference is 12 V obtained. When 2 ampere current passes from negative to positive terminal of the battery potential difference 9 V is obtained, calculate emf and internal resistance of the battery.

(b) A small pulley of radius 20 cm and moment of inertia 0.32 kg m² is used to hang a 2 kg mass with the help of massless string. If this load is released then calculate acceleration of the block.



10.(a) How many photons of wavelength 439 nm should strike on a perfectly reflecting surface in 1 second so that it may exert a force of 10 N ?

(b) Can water be boiled without heating ?

SOLUTIONS

1.(a) The electric field energy of the capacitor

$$= \frac{1}{2}qV = \frac{1}{2}CV^2$$

given $C = 6\ \mu F$ and $V = 6$ volts

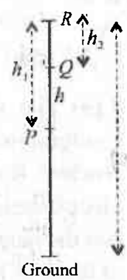
$$\therefore \text{Energy} = \frac{1}{2}\times(6\times10^{-6})36 = 108\times10^{-6}\ J$$

When connected to the inductor, it is given that 1/3 energy is transferred as magnetic field energy i.e.

$$\frac{1}{2}LI^2 = 36\times10^{-6}\ J \quad \text{and} \quad L = 5\ mH\ \text{(given)}$$

$$\therefore I = \sqrt{\frac{36\times10^{-6}\times2}{5\times10^{-3}}} = 0.12\ A.$$

(b) Time taken to fall through a height



$$H = \frac{1}{2}gt^2$$

$$t = \sqrt{\frac{2H}{g}}$$

Time taken to fall through h_1 and H separately is t_p because it will take as much time to go from P to max height, R as from R to P.

Therefore time taken to go from P to R and R to ground is the same as falling from R to ground and R to P.

$$\therefore t_p = \sqrt{\frac{2H}{g}} + \sqrt{\frac{2h_1}{g}}, \quad t_q = \sqrt{\frac{2H}{g}} + \sqrt{\frac{2h_2}{g}},$$

because by the same argument as before, the time taken to fall is separately from R to Q and R to ground is the same as Q to R and R to ground.

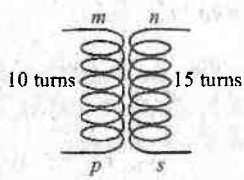
$$(t_p - t)^2 = \frac{2h_1}{g}; \quad (t_q - t)^2 = \frac{2h_2}{g}$$

$$\therefore (t_p - t)^2 - (t_q - t)^2 = \frac{2(h_1 - h_2)}{g}$$

$$i.e.\ (t_p - t)^2 - (t_q - t)^2 = \frac{2h}{g} \quad \text{where } t = \sqrt{\frac{2H}{g}}$$

We assume the total height is H.

2.(a)



Due to a voltage applied in primary, $\frac{-d\phi_s}{dt}$ is induced in secondary this is V_s. Due to a voltage applied in secondary coil $\frac{-d\phi_p}{dt}$ is induced in primary. This is V_p.

$$\frac{V_s}{V_p} = \frac{-d\phi_s/dt}{-d\phi_p/dt} = \frac{I_p}{I_s} \rightarrow \frac{I_p}{I_s} = \frac{\phi_s}{\phi_p}$$

$$\therefore B_p = 1.8\times10^{-4}\times\frac{15}{10}\times\frac{3}{2} = 4.05\times10^{-4}\ \text{weber per turn.}$$

Here B_p is used for the flux per unit turn.

(b) $\upsilon = \frac{n}{2l}\sqrt{\frac{T}{\mu}}$

where $\sqrt{\frac{T}{\mu}}$ is the velocity of the wave.

$$\therefore v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{360}{4\times10^{-3}}} = 300\ m/s$$

Let the harmonics be n and $n + 1$

$$\frac{nv}{2l} = 375\ Hz; \quad \frac{(n+1)v}{2l} = 450\ Hz$$

It is assumed that the length is the same.

$450 - 375 = \frac{300}{2l} \Rightarrow l = 2$ m

$\therefore$ Mass of the string = $2 \times 4 \times 10^{-3} = 8 \times 10^{-3}$ g.

3.(a) The photoelectric equation of Einstein is $h\upsilon = h\upsilon_0 + K.E._{\max}$ for the electrons.

$\therefore \frac{1}{2}mv_{\max}^2 = h\upsilon - h\upsilon_0$

where $h\upsilon_0$ is the work function

$$h\upsilon = \frac{hc}{\lambda} = \frac{12400 \text{ eV Å}}{3300 \text{ Å}} = 3.76 \text{ eV}$$

$\therefore$ Max. K.E. = 3.76 – 2.5 eV = 1.26 eV = 1.3 eV

$\therefore E = 1.3 \times 1.6 \times 10^{-19}$ J

$$qvB = \frac{mv^2}{r} \Rightarrow qB = \frac{\sqrt{2mE}}{r}$$

$$\therefore q = \frac{\sqrt{2mE}}{Br} = \frac{\sqrt{2\times 9\times 10^{-31}\times 1.3\times 1.6\times 10^{-19}}}{6.7\times 10^{-6}\times 0.5}$$

$$\therefore q = \frac{6.1\times 10^{-25}}{6.7\times 0.5\times 10^{-5}} = 1.6\times 10^{-19} \text{ C.}$$

(b) According to Curie's law, in the straight line portion of curve, M vs B/T, if both B and T are tripled, M, the intensity of magnetisation is not affected.

4.(a) Equations for two simple harmonic motions are $y_1 = a\sin(\omega t + \phi_1)$ and $y_2 = a\sin(\omega t + \phi_2)$

If the amplitude and time period do not change, a and ω are the same. The initial phase difference is $\phi_1 - \phi_2$.

Assuming t_0 is the same for both, the sum of the two vectors of displacement maximum is given by

$A^2 = a^2 + a^2 + 2a \cdot a\cos(\phi_1 - \phi_2)$

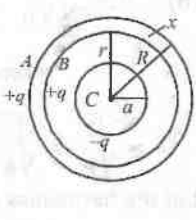
If $A^2 = a^2$, then $a^2 = 2a^2 + 2a^2\cos(\phi_1 - \phi_2)$

i.e. $\cos(\phi_1 - \phi_2) = -1/2$

i.e. $\phi_1 - \phi_2 = 120°$

(b) : Potential at x due to the outer surface, A

at $x = \frac{1}{4\pi\varepsilon_0}\frac{(+q)}{R}$

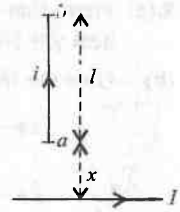


Due to B at $x = \frac{1}{4\pi\varepsilon_0}\frac{(+q)}{x}$

Due to C at $x = \frac{1}{4\pi\varepsilon_0}\frac{(-q)}{x}$

Total potential at $x = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}$.

5.(a) By Ampere's law, the magnetic induction at a point r from the conductor $= \frac{\mu_0 I}{2\pi r}$



The force on the current element idr

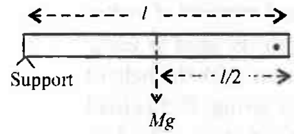
$$\Rightarrow F = \frac{\mu_0 I}{2\pi r} idr \Rightarrow F = \frac{\mu_0 Ii}{2\pi}\cdot\frac{dr}{r}$$

Total force on the conductor of length l placed perpendicularly is

$$F = \frac{\mu_0 iI}{2\pi}\int_x^{l+x}\frac{dr}{r} = \frac{\mu_0 Ii}{2\pi}\ln\frac{l+x}{x}$$

(b) Potential on the surface of a conductor is Kq/r. High potential exists at the portions where radius is small. That is, smaller the radius greater the charge and therefore charge density at that place is also more.

6. **(a):**



Mass M, Torque $= Mg\frac{l}{2} = I\alpha$

$$Mg\frac{l}{2} = M\frac{l^2}{3}\cdot\alpha \Rightarrow Mg\frac{l}{2} = \frac{Ml^2}{3}\cdot\frac{a}{l/2}$$

$$\Rightarrow a = g\frac{l^2}{4}\cdot\frac{3}{l^2} = \frac{3}{4}g = 0.75.$$

(b) $\upsilon = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$

For a wire where μ is mass/unit length, l is the length and T is the tension.

If each one produces 500 Hz, let us assume initially the length, tension and mass are the same.

If by adjusting tension, frequency is changed,

$$\upsilon = \frac{1}{2l}\sqrt{\frac{T}{\mu}} \quad \therefore \ln\upsilon = \ln\left(\frac{1}{2l}\right) + \frac{1}{2}\ln T - \frac{1}{2}\ln\mu$$

Differentiating the variables, υ and T, $\frac{\Delta\upsilon}{\upsilon} = \frac{1}{2}\frac{\Delta T}{T}$

If $\upsilon_2 - \upsilon_1 = \Delta\upsilon = 5$ Hz

$$\frac{\Delta\upsilon}{\upsilon} = \frac{5}{500} = \frac{1}{2}\frac{\Delta T}{T} \Rightarrow \frac{\Delta T}{T} = 2\%.$$

7.(a) The differences between nuclear force and Coulombian force :

Nuclear force is very strong when compared to the electrostatic that is Coulombian force.

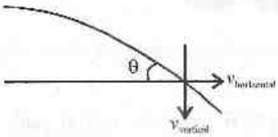
But the range of nuclear force is very small, of the order of fermi or 10^{-15} m whereas electrostatic force has much

larger range.

In the nucleus, even a proton can attract a proton or a neutron. For Coulombian forces, like charges repel and only opposite charges attract.

Coulombian force is electrostatic force; nuclear force does not depend on the sign of the charges in the nucleus.

(b)



$v_H = 100$ m/s

$$v_{vert.} = \sqrt{2gh} = \sqrt{2\times10\times2000} = 200 \text{ m/s}$$

$$\tan\theta = \frac{100 \text{ m/s}}{200 \text{ m/s}} = \frac{1}{2} \therefore \theta = \tan^{-1}\frac{1}{2}.$$

(c) Angular momentum $= \vec{r} \times m\vec{v}$

$= [\text{LMLT}^{-1}] = [\text{ML}^2\text{T}^{-1}]$

Impulse $= F \times \text{time} = [M \cdot a \cdot t]$

$= [\text{MLT}^{-2}\text{T}] = [\text{MLT}^{-1}]$

Energy $= \frac{1}{2}mv^2 = [\text{ML}^2\text{T}^{-2}]$

Torque $= [\vec{r} \times \vec{F}] = [\text{L} \cdot \text{MLT}^{-2}] = [\text{ML}^2\text{T}^{-2}]$

Force $= [\text{MLT}^{-2}]$; Moment of inertia $= [\text{ML}^2]$

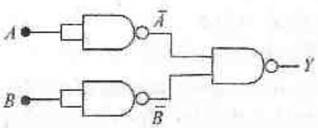
$\therefore$ Energy and torque have the same dimension.

8.(a) $\gamma = \frac{C_P}{C_V}$, the ratio of molar specific heats.

$\gamma = 1 + \frac{2}{f}$ where f is the degree of freedom,

for monoatomic molecules, $f = 3 \Rightarrow \gamma = 5/3$

(b)



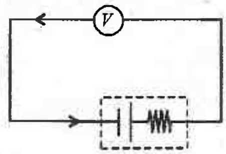
A	B	$\bar{A}$	$\bar{B}$	Y
0	0	1	1	0
0	1	1	0	1
1	0	0	1	1
1	1	0	0	1

$Y = A + B$

$Y = \overline{\bar{A} \cdot \bar{B}} = A + B.$

9.(a) Emf of the battery + 4 amp. × internal resistance is the charging voltage

$12 = \varepsilon + 4r$ ...(1)



when discharging,

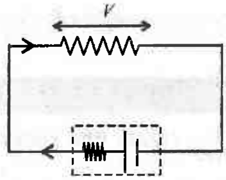
$9 = \varepsilon - 2r$ ....(2)

solving this,

(1) + 2 × (2)

$\Rightarrow 30 \text{ V} = 3\varepsilon;$

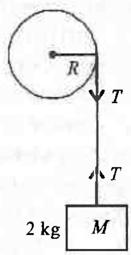
$\varepsilon = 10 \text{ V}, \quad r = \frac{1}{2}\Omega.$



(b) $TR = I\alpha$

$$TR = I\frac{a}{R} \Rightarrow T = \frac{Ia}{R^2}$$

$Mg - T = Ma$



$$\therefore Mg = Ma + T = \left(M + \frac{I}{R^2}\right)a$$

$$a = \frac{Mg}{\left(M + \frac{I}{R^2}\right)} \Rightarrow a = \frac{2\times10}{\left(2 + \frac{0.32}{0.04}\right)}$$

$= 2 \text{ m/s}^2.$

10.(a) Momentum of a single photon $= \frac{h\upsilon}{c} = \vec{p}$

$P_{radiative} = \vec{p}$ per photon

For a perfect reflector change of momentum is twice this value i.e. $2\vec{p}$

For n photons, it is $2np$. This is the total force, if n photons are incident on the area.

Given $\lambda = 439$ nm; force = 10 N, $n = ?$

$$10 \text{N} = 2n \cdot \frac{h\upsilon}{c}$$

$$10 \text{ N} = 2n \cdot \frac{h}{\lambda} \Rightarrow n = \frac{10\times439\times10^{-9}}{2\times6.6\times10^{-34}}$$

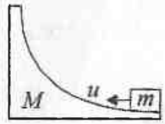
$n = 332.6 \times 10^{25} = 3326 \times 10^{24}$ photons.

(b) As water is converted to steam, higher the pressure, higher the boiling point. At low pressure, water boils fast at low temperature. When the pressure is very low, below the room temperature, water starts boiling without supplying heat.

Thought Provoking Problems in Momentum and Energy conservation

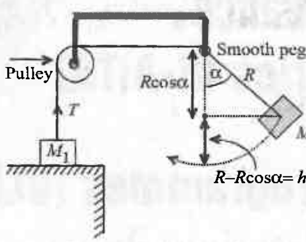
By : Prof. R.S. Randhawa*

1. A small block of mass m is projected from the lowermost point of a smooth wedge of mass M rests on frictionless surface with velocity u. What is the maximum height reached by the block?



2. A smooth ring is kept on a smooth horizontal surface. From point C of the ring a particle is projected at an angle θ to the radius vector at C. If e is the coefficient of restitution between the ring and the particle, show that the particle will return to the point of projection after two reflections if $\tan\theta = \sqrt{\dfrac{e^3}{(1+e+e^2)}}$.

3. Two blocks are connected by a massless string that passes over a frictionless peg as shown in the figure. $M_2 = 6$ kg and $R = 3$ m from the peg. The other end of the string is connected to a block of mass $M_1 = 13$ kg resting on a table. Find the angle α with the vertical due to which 6 kg block be released in order to just lift the 13 kg off the table?



4. A chain of length $L < \dfrac{\pi R}{2}$ is placed on a smooth hemispherical surface of radius R with one of its ends fixed at the top of the sphere, then find the gravitational energy of the chain from the base of the hemisphere.

5. A ball of mass 100 gm is dropped from a height 8 m. It rebounds losing 90% of its total mechanical energy. If it remains in contact with the ground for $\Delta t = 0.02$ sec; find the impulse of the impact force.

SOLUTIONS

1. From conservation of momentum along x-axis

$mu = (m + M)v$ or $v = \dfrac{mu}{M+m}$

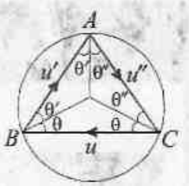
From conservation of energy,

$$\frac{1}{2}mu^2 = \frac{1}{2}(M+m)v^2 + mgh$$

$$\frac{1}{2}mu^2 = \frac{1}{2}\frac{m^2u^2}{(M+m)} + mgh$$

or $h = \dfrac{u^2}{2g}\left[\dfrac{M}{M+m}\right]$

2. From figure -



At point B, $\tan\theta' = \dfrac{u\sin\theta}{eu\cos\theta} = \dfrac{\tan\theta}{e}$

and $u' = \sqrt{u^2\sin^2\theta + eu^2\cos^2\theta}$

Similarly, At point A,

$$\tan\theta'' = \frac{u'\sin\theta'}{eu'\cos\theta'} = \frac{\tan\theta'}{e} = \frac{\tan\theta}{e^2}$$

and $u'' = \sqrt{u'^2\sin^2\theta + eu'^2\cos^2\theta}$

As particles come back at the original position,

$\therefore\ 2(\theta+\theta'+\theta'') = \pi$ or $\tan(\theta+\theta'+\theta'') = \infty$

or $1 - [\tan\theta\tan\theta' + \tan\theta\tan\theta'' + \tan\theta''\tan\theta'] = 0$

or $1 = \dfrac{\tan^2\theta}{e} + \dfrac{\tan^2\theta}{e^2} + \dfrac{\tan^2\theta}{e^3}$.

$\tan^2\theta = \dfrac{e^3}{1+e+e^2}$ $\quad\therefore\quad \tan\theta = \sqrt{\dfrac{e^3}{1+e+e^2}}$.

3. According to principle of conservation of energy,

$$M_2gh = \frac{1}{2}M_2v^2$$

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$$g(R - R\cos\alpha) = \frac{1}{2}v^2 \quad \text{or} \quad v^2 = 2Rg(1-\cos\alpha) \;.......\text{(i)}$$

When M_1 is on the point of being lifted, M_2 is vertical

Now $T - M_1g = M_1a$. But $a \simeq 0$

$$\therefore \quad T - M_1g = 0 \qquad ......\text{(ii)}$$

For M_2, $T = M_2g + M_2\dfrac{v^2}{R}$ ......(iii)

Using (i) and (ii) in (iii), we get

$$M_1g = M_2g + \frac{M_2}{R}\left[2Rg(1-\cos\alpha)\right]$$

$$\therefore \quad \cos\alpha = \frac{3M_2 - M_1}{2M_2} = \frac{3\times 6 - 13}{2\times 6} = \frac{5}{12}, \quad \alpha \approx 65^\circ$$

4. Let mass of the chain is M and its length is $L = TQ$.
Let $PQ = dl$, small element of chain at angle θ which subtends an angle $d\theta$ and its mass is

$$m = \frac{M}{L}(Rd\theta).$$

$\therefore$ Potential energy of small portion of the chain,

$$dU = mgh.$$

From figure, $h = R\cos\theta$.

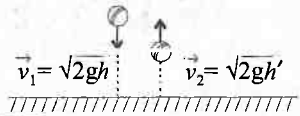
$$dU = \left(\frac{M}{L}\right)Rd\theta \cdot g \cdot R\cos\theta.$$

Total potential energy of the chain

$$U = \left(\frac{M}{L}\right)R^2g\int_0^{L/R}\cos\theta \cdot d\theta$$

$$U = \frac{M}{L}gR^2 \;\sin(L/R).$$

5. $\vec{F}\Delta t = \Delta\vec{p} = m\vec{v}_1 - (-m\vec{v}_2), \; = m(\vec{v}_1 + \vec{v}_2).$ ....(i)



Since $v_1 = \sqrt{2gh}$ and 90% energy is lost

$\therefore$ Final kinetic energy $= \dfrac{1}{2}mv_2^2 = \dfrac{1}{2}mv_1^2 \times \dfrac{10}{100}$

$$v_2 = \frac{v_1}{\sqrt{10}} = \sqrt{\frac{2gh}{10}} = \sqrt{\frac{2\times 10\times 8}{10}} = 4 \text{ ms}^{-1}.$$

And $v_1 = \sqrt{2gh} = \sqrt{2\times 10\times 8} = 4\sqrt{10}\text{ ms}^{-1} = 4\times 3.16$

$= 12.64\text{ ms}^{-1}$.

Put v_1 and v_2 in (i) we get,

Impulse, $I = F\Delta t = m(16.64) = \dfrac{100}{1000}\times 16.64$

$$I = 1.664\text{ Ns}.$$

COMPREHENSIONS

Comprehension 1

Two cars C and D, travel in a straight line. The distance of C from the starting point is given as a function of time by $x_C(t) = \alpha t + \beta t^2$, with $\alpha = 2.60$ m/s and $\beta = 1.20$ m/s². The distance of D from the starting point is $x_D(t) = \gamma t^2 - \delta t^3$, with $\gamma = 2.80$ m/s² and $\delta = 0.20$ m/s².

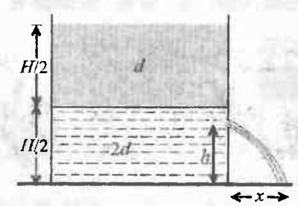
1. Which car is ahead just after they leave the starting point?
(a) Car C moves ahead
(b) Car D moves ahead
(c) Car C and D move simultaneously
(d) Data is insufficient.

2. At what time(s) are the cars at the same point?
(a) 2.27 s (b) 5.73 s
(c) 2.6 s
(d) both 2.27 s and 5.73 s

3. At what time(s) do C and D have the same acceleration?
(a) 6.27 s (b) 4.33 s
(c) 2.67 s
(d) both 6.27 s and 4.33 s

Comprehension 2

A container of large uniform cross-sectional area A resting on a horizontal surface, holds two immiscible, non-viscous and incompressible liquids of densities d and $2d$, each of height $H/2$ as shown in the figure. The lower density liquid is open to the atmosphere having pressure P_0. A homogenous solid cylinder of length $L(L < H/2)$, cross-sectional area $A/5$ is immersed such that it floats with its axis vertical at the liquid-liquid interface with length $L/4$ in the denser liquid. The cylinder is then removed and the original arrangement is restored. A tiny hole of area $s(s << A)$ is punched on the vertical side of the container at a height $h(h < H/2)$. As a result of this, liquid start flowing out of the hole with a range x on the horizontal surface.



4. The density D of the material of the floating cylinder is
(a) $5d/4$ (b) $3d/4$
(c) $4d/5$ (d) $4d/3$.

5. The total pressure at the bottom of the container is
(a) $P_0 + \frac{(6L+H)}{4}dg$ (b) $P_0 + \frac{(L+6H)}{4}dg$
(c) $P_0 + \frac{(L+6H)}{2}dg$ (d) $P_0 - \frac{(L+6H)}{4}dg$

6. The initial speed of efflux of the liquid at the hole is
(a) $v = \sqrt{\frac{g}{2}[3H+4h]}$ (b) $v = \sqrt{\frac{g}{2}[4H-3h]}$
(c) $v = \sqrt{\frac{g}{2}[3H-4h]}$ (d) $v = \sqrt{\frac{g}{2}[4H+3h]}$

7. The horizontal distance travelled by the liquid, initially, is
(a) $\sqrt{(3H+4h)h}$ (b) $\sqrt{(3h+4H)h}$
(c) $\sqrt{(3H-4h)H}$ (d) $\sqrt{(3H-4h)h}$

8. The maximum horizontal distance travelled by the liquid is to
(a) $x_{max} = \frac{H}{4}$ (b) $x_{max} = \frac{2H}{4}$
(c) $x_{max} = \frac{3H}{4}$ (d) $x_{max} = \frac{5H}{4}$

Comprehension 3

A ball of radius R carries a positive charge whose volume charge density depends only on the distance r from the ball's centre as $\rho = \rho_0\left(1 - \frac{r}{R}\right)$.
where ρ_0 is a constant. Assume ε as the permittivity of

the ball.

9. The magnitude of electric field as a function of the distance r inside the ball's is given by

(a) $E = \frac{\rho_0}{\varepsilon}\left[\frac{r}{3} - \frac{r^2}{4R}\right]$ (b) $E = \frac{\rho_0}{\varepsilon}\left[\frac{r}{4} - \frac{r^2}{3R}\right]$

(c) $E = \frac{\rho_0}{\varepsilon}\left[\frac{r}{3} + \frac{r^2}{4R}\right]$ (d) $E = \frac{\rho_0}{\varepsilon}\left[\frac{r}{4} + \frac{r^2}{3R}\right]$

10. The magnitude of the electric field as a function of the distance r outside the ball is given by

(a) $E = \frac{\rho_0 R^3}{8\varepsilon r^2}$ (b) $E = \frac{\rho_0 R^3}{12\varepsilon r^2}$

(c) $E = \frac{\rho_0 R^2}{8\varepsilon r^3}$ (d) $E = \frac{\rho_0 R^2}{12\varepsilon r^3}$

11. The value of distance r_m, at which electric field intensity is maximum, is given by

(a) $r_m = \frac{R}{3}$ (b) $r_m = \frac{3R}{2}$

(c) $r_m = \frac{2R}{3}$ (d) $r_m = \frac{4R}{3}$

12. The maximum electric field intensity is

(a) $E_m = \frac{\rho_0 R}{9\varepsilon}$ (b) $E_m = \frac{\rho_0 \varepsilon}{9R}$

(c) $E_m = \frac{\rho_0 R}{3\varepsilon}$ (d) $E_m = \frac{\rho_0 R}{6\varepsilon}$

SOLUTIONS

1. **(a) :** $x_C = \alpha t + \beta t^2$; $x_D = \gamma t^2 - \delta t^3$

$$v_C = \frac{dx_C}{dt} = \alpha + 2\beta t$$

$$v_D = \frac{dx_D}{dt} = 2\gamma t - 3\delta t^2$$

$$a_C = \frac{dv_C}{dt} = 2\beta \ ; \quad a_D = \frac{dv_D}{dt} = 2\gamma - 6\delta t$$

The car that initially moves ahead is the one that has larger velocity at $t = 0$. At $t = 0$, $v_C = \alpha$ and $v_D = 0$

So initially car C moves ahead.

2. **(d):** $x_C = x_D$ (cars at same point)

$\alpha t + \beta t^2 = \gamma t^2 - \delta t^3$

one solution is $t = 0$, which suggests that they start from the same point. To find the other solution, divide by t.

i.e. $\alpha + \beta t = \gamma t - \delta t^2$

$$t = \frac{1}{2\delta}\left[-(\beta - \gamma) \pm \sqrt{(\beta - \gamma)^2 - 4\delta\alpha}\right]$$

$$= \frac{1}{0.40}\left[+1.60 \pm \sqrt{(1.60)^2 - 4(0.20)(2.60)}\right]$$

$= 4.00$ sec $\pm$ 1.73 sec

Hence, $x_C = x_D$ for $t = 0$, $t = 2.27$ sec and $t = 5.73$ sec.

3. **(c) :** For the same acceleration

$a_C = a_D$ $\quad \therefore 2\beta = 2\gamma - 6\delta t$

or $t = \frac{\gamma - \beta}{3\delta} = \frac{2.80 - 1.20}{3(0.20)} = 2.67$ sec.

4. **(a) :** According to principle of floatation, net buoyant force = weight of cylinder

or $\frac{A}{5} \times \frac{L}{4} \times 2dg + \frac{A}{5} \times \frac{3L}{4} \times dg = \frac{A}{5} \times LDg$

where $A/5$ is the cross-sectional area of the cylinder and D is the density of the material of the cylinder.

$\therefore D = \frac{3}{4}d + \frac{2}{4}d$

$\therefore D = 5d/4$.

5. **(b) :** Total pressure at the bottom of the container

$$P = \frac{\text{weight of liquid + weight of cylinder}}{A} + \text{Atmospheric pressure}$$

$$= \frac{[Ad(H/2)g + A2d(H/2)g] + [(A/5) \times (5d/4)Lg]}{A} + P_0$$

$$= dg\left[\left(\frac{H}{2} + H\right) + \frac{L}{4}\right] + P_0 = \frac{(6H + L)dg}{4} + P_0.$$

6. **(c) :** According to Bernouilli's theorem

$$P_0 + dg(H/2) + 2dg\left(\frac{H}{2} - h\right) = \frac{1}{2}(2d)v^2 + P_0$$

Solving, we get : $v = \sqrt{\frac{g}{2}(3H - 4h)}$.

7. **(d) :** Time taken by the liquid to reach the ground is t

$$\therefore t = \sqrt{\frac{2h}{g}}$$

$$\therefore x = vt = \sqrt{\frac{g}{2}(3H - 4h)} \times \sqrt{\frac{2h}{g}} = \sqrt{(3H - 4h)h}.$$

8. **(c) :** For maximum distance x_{max},

$$\frac{dx}{dh} = 0 \text{ or } h = \frac{3H}{8}$$

$$\therefore x_{max} = \sqrt{\left[3H - \frac{12H}{8}\right]\frac{3H}{8}} = \frac{3H}{4}.$$

9. **(a) :** The given charge distribution in the ball is not uniform but varies w.r.t. distance from the centre. In order to calculate the electric field due to it, the ball can be assumed to be made of various concentric spherical shells. Let us consider one such spherical shell having radius r and thickness dr. Volume of the elementary spherical shell $= 4\pi r^2 dr$.

Hence, charge contained in the volume

$$dq = 4\pi r^2 dr\rho = 4\pi r^2 dr\rho_0\left[1 - \frac{r}{R}\right]$$

$$= 4\pi\rho_0\left[1 - \frac{r}{R}\right]r^2 dr$$

Hence, charge contained within the volume of a sphere of radius $r (r < R)$ is :

$$q = \int dq = 4\pi\rho_0\int_0^r\left[1 - \frac{r}{R}\right]r^2 dr = 4\pi\rho_0\left[\frac{r^3}{3} - \frac{r^4}{4R}\right]$$

Now the electric field E at a distance r from the centre of ball can be calculated as if the charge q is concentrated at the centre of the ball.

$$E = \frac{1}{4\pi\varepsilon}\frac{q}{r^2} = \frac{1}{4\pi\varepsilon}4\pi\rho_0\left[\frac{r^3}{3} - \frac{r^4}{4R}\right]\frac{1}{r^2} = \frac{\rho_0}{\varepsilon}\left[\frac{r}{3} - \frac{r^2}{4R}\right]$$

10. **(b) :** For calculating the electric field outside the ball, we should calculate first the total charge present in the ball, i.e.,

$$Q = 4\pi\rho_0\int_0^R\left[1 - \frac{r}{R}\right]r^2 dr$$

$$= 4\pi\rho_0\left[\frac{R^3}{3} - \frac{R^4}{4R}\right] = 4\pi\rho_0\left(\frac{R^3}{12}\right)$$

Again to find the electric field outside the ball, total charge Q will be considered to be concentrated at the centre. Hence, electric field at a distance r from the centre of ball.

$$E = \frac{1}{4\pi\varepsilon}\frac{Q}{r^2} = \frac{1}{4\pi\varepsilon}4\pi\rho_0\left(\frac{R^3}{12}\right)\times\frac{1}{r^2} = \frac{\rho_0 R^3}{12\varepsilon r^2}$$

11. **(c) :** For E to be maximum :

$$\frac{dE}{dr} = 0 \text{ or } \frac{\rho_0}{\varepsilon}\left[\frac{1}{3} - \frac{2r}{4R}\right] = 0 \text{ or } r_m = \frac{2R}{3}.$$

12. **(a) :** $\therefore E_m = \frac{\rho_0}{\varepsilon}\left[\frac{r_m}{3} - \frac{r_m^2}{4R}\right]$

$$= \frac{\rho_0}{\varepsilon}\left[\frac{2R}{9} - \frac{4R^2}{36R}\right] = \frac{\rho_0}{\varepsilon}\left(\frac{R}{9}\right).$$

❖

Train *Your* Brain

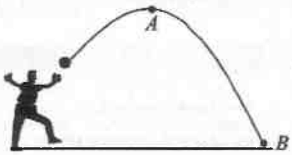
This exercise will give your brain the workout it needs!

Australian Physics Olympiad Problems

SECTION - A

Multiple Choice Questions with one correct answer

1. A ball is thrown into the air and it moves in the path shown here. Ignore air resistance in this question.



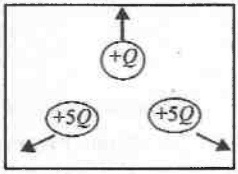
At position A the ball is at the highest point in its path, position B is just before it hits the ground. Which of the following statements is true?

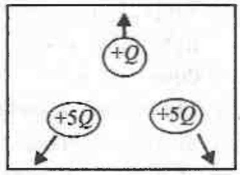
(a) The speed of the ball at A is zero and the acceleration of the ball at B is the same as at A.
(b) The speed of the ball at A is the same as the speed at B and the acceleration at B is higher than at A.
(c) The speed at A is lower than the speed at B and the acceleration at A is higher than the acceleration at B.
(d) The speed at A is lower than the speed at B and the acceleration at A is the same as the acceleration at B.
(e) The speed at A is higher than the speed at B and the acceleration at A is the same as the acceleration at B.

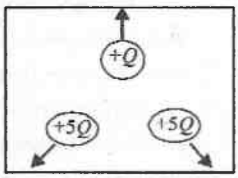
2. A person at a distance R from the centre of the earth (where R is greater than the radius of the earth) is attracted towards the earth by a gravitational force of 400 newtons. How far away from the centre of the earth must the person be for the gravitational force to be 100 newtons?

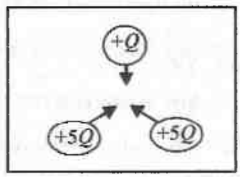
(a) $\frac{1}{4}R$ (b) $\frac{1}{2}R$ (c) $2R$ (d) $4R$
(e) $16R$.

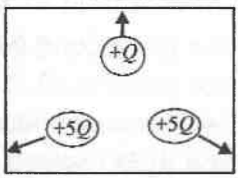
3. Three uniformly charged balls lie at the corners of an equilateral triangle. Each ball is positively charged, with the charges as shown in the diagrams below. Which of the diagrams below correctly indicates the direction and magnitude of the electrostatic force acting on each of the balls?

(a)


(b)


(c)


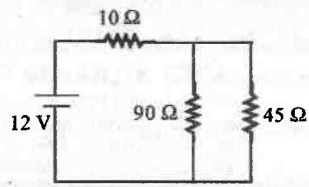
(d)


(e)


4. A truck weighing 6000 kg runs into a car weighing 800 kg. The truck was moving at 15 ms^{-1}, and the car was at rest. Assume that the truck and the car continue moving together. What is the final speed of the combined car/truck system?

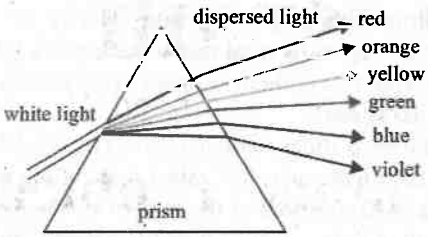
(a) 1.8 ms^{-1} (b) 7.5 ms^{-1} (c) 13 ms^{-1} (d) 17 ms^{-1}
(e) 113 ms^{-1}.

5. In the circuit shown here there is a current of 0.3 ampere flowing through 10 Ω resistor. How much current flows through the 90 Ω resistor?



(a) 0 A (b) 0.1 A (c) 0.15 A (d) 0.2 A
(e) 0.3 A.

6. When a beam of white light is shone into a glass prism, a rainbow appears as shown in the below diagram.



This phenomenon is known as dispersion. Which explanation best describes why this occurs?

(a) Different frequencies of light meet at different angles on the glass surface, meaning that they refract at different angles, as according to Snell's law.

(b) Violet light is affected by gravity more than red light, because it is more energetic, hence it is pulled down more.

(c) The refractive index of glass depends on frequency.

(d) Snell's law breaks down when different frequencies of light are combined, creating strange quantum relativistic effects which cause dispersion.

(e) This effect is an optical illusion and the light is not actually dispersed.

7. Colin claims to have invented a machine that removes heat energy from the air and converts it into electricity. The entire machine is at the same temperature as the surrounding air and does not have an external power supply. Can Colin's machine work?

(a) Yes, it can.

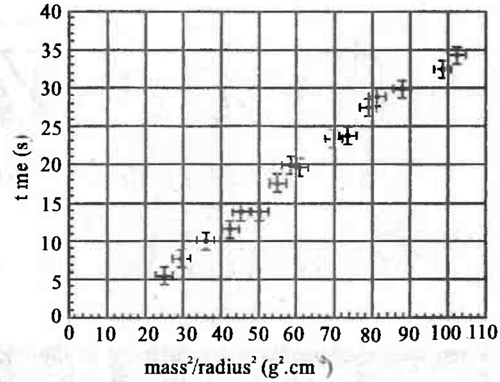
(b) No, it cannot, because there is no electricity in the air.

(c) No, it cannot, because there will be no net flow of energy from the air into a machine at the same temperature.

(d) No, it cannot, because it would violate conservation of energy.

(e) No, it cannot because heat energy cannot be converted into electrical energy.

8. Measurements of time, t, were taken as a function of mass m, and radius r. The relationship between time, mass and radius is of the form $t = k\frac{m^2}{r^2} + q$ where k and q are constants. From the graph below, find the value of k. Hint : Remember that the equation of a straight line can be written as $y = mx + c$.



(a) 0.33 $cm^2.s.g^{-2}$ (b) 0.38 $cm^2.s.g^{-2}$

(c) 0.33 $g^2.cm^{-2}.s^{-1}$ (d) 0.38 $g^2.cm^{-2}.s^{-1}$

(e) 2.63 $g^2.cm^{-2}.s^{-1}$.

9. Dimensional analysis is an important technique in physics which allows one to check an equation for plausibility. If the dimensions on each side of an equation are identical, the equation is dimensionally correct. If not, the equation cannot be correct. There are five fundamental dimensions. These are length L, mass M, time T, charge Q and temperature K. Pure numbers, such as π, have no dimensions. For example, the speed of light c is a measure of length per unit time, and has dimensions of LT^{-1}. The table below lists some quantities and their dimensions.

Quantity	Dimensions
Energy, E	ML^2T^{-2}
Current, I	QT^{-1}
Viscosity, η	$ML^{-1}T^{-1}$
Momentum, p	MLT^{-1}
Inductance, L	ML^2Q^{-2}
Planck's constant h	ML^2T^{-1}.

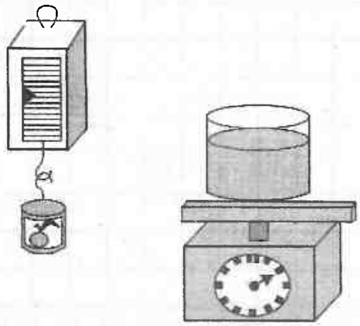
Using this information, which of the following equations cannot be correct?

(a) $E = hc/\lambda$ (b) $E^2 = p^2c^2 + m^2c^4$

(c) $E = \frac{1}{2}mv^2$ (d) $E = 6\pi\eta va$

(e) $E = \frac{1}{2}LI^2$.

10. A tin of peaches is hanging from a spring balance. Nearby a bucket of water sits on a set of scales, as shown below. The tin of peaches, still hanging from the spring balance is immersed in the bucket of water. Which of the following statements is true?



(a) When the tin of peaches is immersed in the water the reading on the spring balance decreases and the reading on the scales increases.
(b) When the tin of peaches is immersed in the water the reading on the spring balance increases and the reading on the scales decreases.
(c) When the tin of peaches is immersed in the water the reading on the spring balance decreases and the reading on the scales stays the same.
(d) When the tin of peaches is immersed in the water the reading on both the spring balance and the scales stays the same.
(e) When the tin of peaches is immersed in the water, the reading on both the spring balance and the scales increases.

SECTION - B

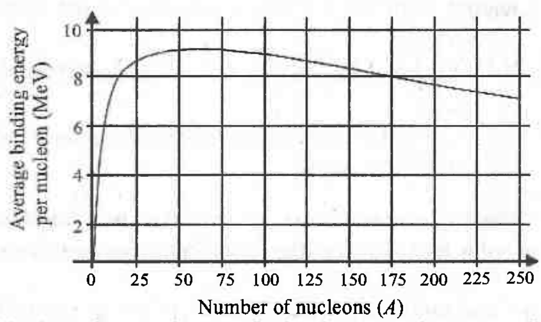
Long Answer Questions

11. A hoop of mass m and radius R is rolling without slipping with a velocity v along a flat surface. That is, the centre of the hoop is moving with a constant velocity v and the bottom of the hoop, which is touching the ground, is not slipping along the ground but is stationary. As it rolls the point which was in contact with the ground moves up off the ground and the hoop rests on a new point on its circumference. As the point in contact with the ground is continuously changing any particular point is only on the ground for an instant; remember that for that instant its velocity is zero.
(a) How long does it take for the same point on the circumference of the hoop to be in contact with the ground again? Draw appropriate diagrams as part of your answer.
(b) Express the number of revolutions the hoop completes in one second, n, in terms of the velocity and radius of the hoop.
(c) Find the rotational kinetic energy, K_r, of the hoop in terms of R, m and n.
(d) What is the total kinetic energy K, of the hoop if it is rolling without slipping with velocity, v?
(e) If the hoop starts from rest at the top of a hill with height h and rolls without slipping to the bottom, what is its final speed?
(f) If the hoop slides without rolling (ignoring kinetic friction) down the same hill, rather than rolling without slipping, will its speed at the bottom be the same as, greater than or less than if it rolled without slipping? Why?

12. In this question, we will be investigating nuclear fission and fusion. Fission is the process by which a nucleus of an atom is split into two smaller nuclei. Fusion is the opposite process: two smaller nuclei are combined to create a larger nucleus.
The nucleus of an atom is composed of a number of smaller particles called nucleons. When the nucleons are brought together to form a nucleus, a certain amount of energy is released. As a consequence, a certain amount of energy (called the binding energy) is required to separate a nucleus into its individual nucleons. This binding energy can be seen as a difference in mass between the nucleus and the combined mass of its nucleons using Einstein's famous equation $E - mc^2$, where c is the speed of light. Using this, we can find an expression for the mass of the nucleus in terms of the binding energy and the combined mass of the nucleons:

$$\text{(mass of nucleus)} \times c^2 = \text{(combined mass of nucleons)} \times c^2 - \text{binding energy}$$

In the graph below, the average binding energy per nucleon in the nucleus is plotted against the total number of nucleons in the nucleus. Note that MeV (mega-electron volts) is a unit for measuring energy.



(a) A nucleus undergoes fission into exactly two smaller equal-sized nuclei. If the larger nucleus has a total binding energy of 50 MeV and the smaller nuclei have a binding energy of 40 MeV each, will this process release energy

or require energy to occur? How much energy will be released/required in MeV?

(b) Explain with reference to the above graph why larger nuclei can undergo fission without an external source of energy, but smaller nuclei (< 50 nucleons) cannot. Assume that the products of fission have the same number of nucleons each.

(c) Is it possible for a fusion reaction to release energy? Why/Why not? If so, what is (roughly) the minimum (or maximum) number of nucleons two identical nuclei must each have for a fusion reaction between them to release energy?

(d) If a uranium nucleus with 236 nucleons undergoes fission into two nuclei with 118 nucleons each, how much energy is released in this reaction in MeV?

13. Consider a helicopter hovering at some height above the ground.

(a) Draw a free body diagram showing the forces acting on the helicopter?

(b) What is the force that acts against gravity to keep the helicopter in the air, and what exerts this force on the helicopter?

(c) Find an expression for the rate R, at which air flows past the blades (mass per unit time) in terms of the air velocity v, air density ρ, and the area swept out by the blades.

(d) Show that the force exerted by the helicopter blades on the air $F = A\rho v^2$.

(e) A particular helicopter can hover if its engine produces mechanical power P. A scale model which is identical to this first helicopter is built, such that it is an exact $\frac{1}{2}$ -scale replica (in all linear dimensions). Using the results from the previous parts, what mechanical power, in terms of P, is required for this smaller helicopter to hover?

14. This question concerns two balloons and two cylinders of gas. One cylinder contains helium, a monoatomic gas of molecular mass 4 g mol^{-1}. The other contains nitrogen, a diatomic gas of molecular mass 28 g mol^{-1}. The balloons are identical, and each is connected to one of the cylinders. Both gases may be assumed to be ideal, and both cylinders weigh the same amount. Ideal gases have the property that their molecules do not interact other than through elastic collisions, and that the pressure in a container of ideal gas is inversely proportional to the volume, and directly proportional to the temperature and number of moles of gas.

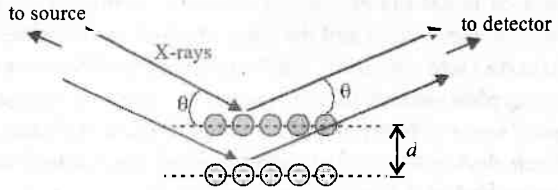
(a) Which balloon will be inflated faster when the cylinders are opened? Carefully explain your reasoning using physical arguments?

(b) Compare the sizes of the helium-filled balloon and the nitrogen-filled balloon. Which, if either, will be bigger? Explain your answer.

(c) Find expressions for the final temperatures of the gases in both balloons in terms of the initial temperature T and other variables previously defined.

(d) Hence find the difference between the volumes of the two balloons after the heating.

15. X-rays are a form of high energy light which can be used in medical imaging and to investigate the structure of solids. It is used because the X-rays have very short wavelengths and hence are useful for seeing very small things using interference and diffraction of the X-rays. Consider X-rays with wavelength λ incident on a crystal, as shown below.



The spacing between layers of atoms can be found by measuring the angles at which constructive interference occurs.

(a) Draw a diagram showing the path difference between the two reflected rays shown above.

(b) Find an expression for the path difference between the two rays.

(c) Find the condition on the incident angle, θ, as defined in the diagram above, for constructive interference.

(d) Consider a crystal which has a spacing of 5.5×10^{-10} m between layers of atoms. The incident X-ray have a wavelength $\lambda = 1.54 \times 10^{-10}$ m. Find the two smallest angles (in degrees) for which there will be constructive interference of the reflected X-rays.

A highly reactive crystal is stored under oil to prevent it oxidising explosively in air. The oil has a refractive index of 1.6 for X-rays. X-rays of wavelength $\lambda = 1.54 \times 10^{-10}$ m are used to find the spacing between layers of atoms in this crystal. The X-ray source and detector are arranged as shown below with the sample kept under oil while measurements are made.

or require energy to occur? How much energy will be released/required in MeV?

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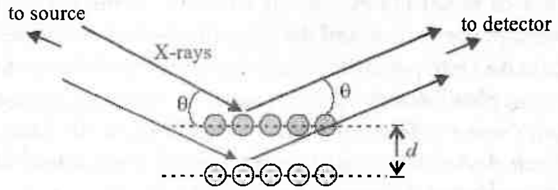

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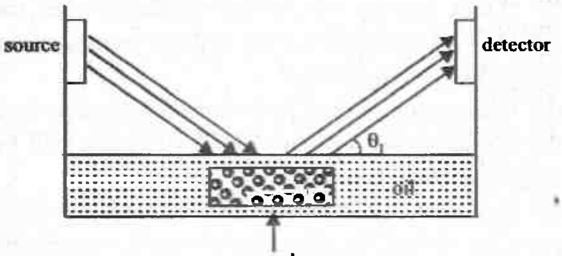


(e) Find an expression for the incident angle in the oil at which constructive interference will occur.
(f) The angle θ_1, between the oil surface and the path to the detector for constructive interference is 6.8° for the first angle at which constructive interference occurs. Calculate the spacing between the planes of atoms. Show all your working and include a diagram.

16. An enterprising student has a collection of ball-shooting machines, which fire negatively charged balls of mass m and charge $-q$. The machine consists of a pair of metal plates, one of which is connected to a voltage supply line and the other of which is connected to earth (zero potential). Balls are accelerated from rest at one plate towards the other, and then leave the machine with some velocity v from a small hole in the plate. Each device draws a constant current i regardless of the potential difference between the plates.
The student connects N of these devices to a generator providing a constant positive potential of V (with respect to earth) by a chain of power boards. The resistance between one board and the next (and between the generator and the first board) is r. Each board then has one machine and one more board plugged into it, except for the last board, which has only a machine.
(a) Draw a diagram of the device showing the two plates, making which one is the positive and which the zero, and draw in the electric field and the direction of the acceleration of one of the balls.
(b) If the balls are to have velocity at least v as they leave the machine, find the minimum potential which needs to be applied to the positive plate.
(c) The devices are connected as described above. Draw a circuit diagram representing this situation. Represent the resistances between the boards as resistors, the generator as a battery, and the ball-shooting machines as circles with the letter B inside. Mark in the currents flowing through the devices. (Note that you do not have to show all of the machines, just a couple so that the pattern is obvious.)
(d) What is the total current flowing through the first resistor, *i.e.* that between the generator and the first machine?
(e) What is the potential difference across this first resistance, and hence what is the potential applied to the first device?
(f) What is the potential applied to the last (N^{th}) device in the chain?
(g) How many devices may the student connect before the last one in the chain fails to accelerate balls to velocity v?

SOLUTIONS

SECTION-A

1. **(d)** : The ball has a constant horizontal velocity and the ball has a constant acceleration downwards due to gravity. The vertical velocity of the ball is zero at A, and some value (not zero) downwards at B. Thus, at B, the ball is at a higher speed than at A.

2. **(c)** : The force due to gravity is given by $F = \frac{GMm}{R^2}$.
As G, M and m do not change, one can write an equation for the first force F_1, and the second force F_2, in terms of R_1 and R_2 as the respective radii.
Dividing the first equation by the second leads to the ratio $\frac{F_1}{F_2} = \left(\frac{R_2}{R_1}\right)^2 = \frac{400\text{ N}}{100\text{ N}} = 4 = 2^2$.
Thus, $R_2 = 2R_1$.

3. **(e)** : The force due to charged particles is proportional to the product of the charges (Coulomb's law), so the force between the $+Q$ charge and a $+5Q$ charge will be proportional to $5Q^2$ and repulsive, whilst between the two $+5Q$ charges the force will be proportional to $(5Q)^2 = 25Q^2$. Drawing a careful diagram which resolves the forces will give the correct answer.

4. **(c)** : This is a question of conservation of momentum.
$p_i = p_f$ (p is momentum)
Momentum = mass × velocity
Thus, $6000 \times 15 = (6000 + 800) \times v_f$
Rearranges to solve for v_f (final velocity),
$$\frac{6000 \times 15}{(6000+800)} = v_f \Rightarrow v_f = \frac{90000}{6800} = 13\text{ ms}^{-1}.$$

5. **(b)** : If there is 0.3 ampere flowing through the 10 ohm resistor, then there must be 0.3 ampere flowing through the combined 90 ohm and 45 ohm resistors.

There is the same voltage across both the 90 ohm and the 45 ohm resistors.
Using $V = IR$, there will be half as much current going through the 90 ohm resistor as through the 45 ohm resistor, and thus the current will be split in a ratio of 1 : 2. Thus, 0.1 ampere will pass through the 90 ohm resistor, and 0.2 ampere through the 45 ohm resistor.

6. (c) : The answer is (c) through prior knowledge however, this question does not necessarily require knowledge of how dispersion works, but can be worked out logically. (a) is incorrect, as the beam of white light meets the prism at a set angle, and white light is composed of light of various colours. (b) is incorrect, there is no gravitational direction presented here.
Light acts as a wave, and waves obey superposition so the combination of different frequencies does not have "strange quantum relativistic effects". This effect is quite real and observable, so (e) is incorrect.

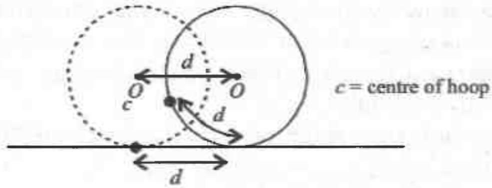
7. (c) : Energy can be converted from one form to another, hence there is no need for there to be electricity in the air, and conservation of energy need not be violated. Heat energy can be converted into electrical energy. To take energy out of the air and into the machine requires the machine to be cooler than the air, otherwise there will be no net flow of heat. Hence (a) is incorrect and (c) is the correct answer.

8. (b) : The gradient of the line of best fit for this graph is the constant k. The dimensions of the gradient, k, must be $cm^2\ s\ g^{-2}$. Drawing a line of best fit and finding the gradient gives the correct value for k of $0.38\ cm^2\ s\ g^{-2}$, hence the correct answer is (b). Note that forcing the line through the origin results in the incorrect answer (a).

9. (d) : Using the information provided to find the dimensions for the right hand side of each question and compare these to the dimensions for energy, which are ML^2T^{-2}, the correct is (d) which has dimensions of MLT^{-2}, which is a force.
Whether it is $E = 6\pi\eta vd$ is given or $6\pi\eta va$, both the diameter and the radius have the same dimension. But $6\pi a\eta v$ is the Stoke's equation for viscous force.

10. (a) : When the tin of peaches is lowered into the water, buoyancy will reduce its effective weight, meaning that it will weigh less according to the spring balance. However, by Newton's 3rd law, the tin of peaches exerts a force on the water, which then exerts this force on the scales. Hence the measuring scales will show an increased weight.
Thus, the spring balance shows a decreased weight and the measuring scales show an increase in weight.

11. (a) As the hoop rolls each point on its circumference comes into contact with the ground. When the centre of the hoop has moved a distance d the point of the hoop in contact with the ground is a distance d further along the hoop's circumference. The figure below illustrates this.



The hoop must travel the length of its circumference for the same point on the hoop to be in contact with the ground again.
The hoop moves with a constant velocity v so the time it takes to travel a distance d is $t = d/v$.
The time it takes for the same point on the hoop to be in contact with the ground again is $T = \frac{2\pi R}{v}$.
(b) If T is the time for one revolution, the number of revolutions that occur in one second is $n = 1/T$.

So $n = \frac{v}{2\pi R}$.
The total kinetic energy of a body is its rotational kinetic energy plus its translational (linear) kinetic energy. The rotational kinetic energy of a body is calculated by finding the kinetic energy of the body if its translational velocity were zero. Similarly the translational kinetic energy is calculated by finding the kinetic energy of the body if it were not rotating.
(c) If the hoop's translational velocity was zero but it was still rotating n times per second the velocity of any point on its circumference would be the distance it travels during one rotation times the number of rotations per second.
So $v_r = 2\pi Rn$ and since all the mass of the hoop is at its circumference the rotational kinetic energy of the hoop:

$$K_r = \frac{1}{2}mv_r^2 = \frac{1}{2}I\omega^2 = \frac{1}{2}\times mR^2\times 4\pi^2n^2$$

$\Rightarrow\ K_r = mR^2\,2\pi^2n^2$.
(d) The translational kinetic energy of the hoop is

$$K_t = \frac{1}{2}mv^2$$

The total kinetic energy of the hoop is

$$K = K_t + K_r = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$= \frac{1}{2}mv^2 + \frac{1}{2}mR^2 \times \frac{v^2}{R^2} = mv^2.$$

(e) The easiest method for solving this problem is to use conservation of energy. At the top of the hill the hoop has no kinetic energy and a higher gravitational potential energy than at the bottom. For convenience set the zero for gravitational potential energy at the bottom of the hill.

When the hoop is at the top of the hill the gravitational potential energy $U_{top} = mgh$ and $K_{top} = 0$.

When the hoop is at the bottom,

$U_{bottom} = 0$ and $K_{bottom} = mv^2$.

Applying conservation of energy,

$U_{top} + K_{top} - U_{bottom} + K_{bottom}$

So, $mgh = mv^2$ and the speed at the bottom of the hill,

$$v = \sqrt{gh}.$$

(f) If the hoop slides without rolling its translational kinetic energy is its total kinetic energy.

So $K = \frac{1}{2}mv^2$.

This means that two identical hoops, one sliding and one rolling without slipping, with the same speed do not have the same kinetic energy. The rolling hoop has a higher kinetic energy.

As the hoop travels down the hill the gravitational potential energy is converted to kinetic energy so at the bottom of the hill, they have the same kinetic energy and the rolling hoop has a lower speed.

Quantitatively, applying conservation of energy as in part (e),

$U_{top} + K_{top} - U_{bottom} + K_{bottom}$

$$mgh = \frac{1}{2}mv^2.$$

So the final speed at the bottom of the hill, $v = \sqrt{2gh}$ if the hoop slides.

This speed is greater than the speed calculated in part (e) as expected.

12. (a) If we call the larger nucleus A and the smaller (daughter) nucleus B, the process described in the question can be represented by the equation

$A \rightarrow B + B.$

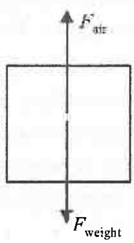
The nucleus A has 50 MeV of binding energy, and each B nucleus has 40 MeV of binding energy. Thus, the two B nuclei have a combined binding energy of 80 MeV. This means that forming the A nucleus from separate nucleons would release 50 MeV, while forming the two B nuclei would release 80 MeV. As no nucleons were gained or lost in this process, 30 MeV of energy must be released.

(b) When large nuclei (of more than about 100 nucleons) fission, the smaller daughter nuclei will have a higher binding energy per nucleon (as seen from the graph), and hence the process will release energy. If small nuclei (less than about 50 nucleons) were to fission, the binding energy per nucleon of the daughter nuclei would be smaller than the binding energy per nucleon of the parent nucleus. Hence, this process would require an external source of energy to occur and so will not occur spontaneously.

(c) It is possible for a fusion reaction to release energy. When two small nuclei fuse together, their binding energy can increase. For example, when two nuclei with 5 nucleons each fuse together and form a nucleus with 10 nucleons, the total binding energy increases from $2 \times 5 \times 5$ MeV = 50 MeV to 10×7 MeV = 70 MeV, hence 20 MeV of energy would be released by this process. If the sum of the binding energy of two identical nuclei is greater than the binding energy of a nucleus twice that size, then fusion of the two smaller nuclei will require energy. As the maximum of the graph is at 50 nucleons, fusion of two nuclei with 25 nucleons each will release energy, while fusion of two nuclei with 50 nucleons each will require energy. Hence the maximum number of nucleons each that two nuclei can have for a fusion reaction between them to release energy will be between 25 and 50 nucleons. From the graph, it can be shown that the exact answer is 40 nucleons.

(d) From the graph, uranium has a binding energy of ~7.5 MeV per nucleon, and a nucleus with 118 nucleons would have a binding energy of ~8.5 MeV per nucleon. This is a difference of 1 MeV per nucleon. As the binding energy has increased, this process will release energy. The amount of energy released will be 236 nucleons × 1 MeV/nucleon = 236 MeV.

13. (a)



where $F_{weight} = mg$ is the force due to gravity acting downwards on the helicopter and F_{air} is the force exerted by the air on the helicopter, pushing the helicopter upwards. Any reasonable upward force was accepted here as a correct answer.

(b) The force that acts against gravity to push the helicopter upwards is the reaction force of the air being pushed down by the rotors. By Newton's third law, since air is being pushed down by the rotors, the rotors must be pushed up by the air. Hence the air exerts this force. The power required for the helicopter to hover is equal to the downward force applied to the air by the helicopter blades times the mean velocity v, of the downward moving column of air beneath its rotor blades.

(c) The volume of air coming out of the rotors is cylindrical, with area A being the area swept out by the blades, and some arbitrary height h. The volume of air passing through the blades per unit time is $A\frac{\Delta h}{\Delta t} = Av$, where v is the velocity of air through the blades. To get the mass flow rate, we need to simply multiply by the density, to get $R = A\rho v$ which was the required expression. Note that this could also be arrived at using dimensional analysis.

(d) This problem requires the definition of force as the rate of change of momentum.

$$F = \frac{\Delta p}{\Delta t}$$

Using the definition of momentum as $p = mv$, we can write

$$F = \frac{\Delta(mv)}{\Delta t} = v\frac{\Delta m}{\Delta t} = vR = A\rho v^2, \text{ as required.}$$

(e) What we are looking for here is the relationship between power and length, how is power proportional to the length in any direction of the helicopter?

We can start with $P = Fv$, the power needed is equal to the force exerted by the air multiplied by the velocity of the air. The force must be at least equal to the weight of the helicopter - mg.

So force scales as $F \propto m \propto l^3$.

Now we need to know how v varies with l. We can use our expression for force from part (d). $F = A\rho v^2$. From this we can say that $A\rho v^2 \propto l^3$. As ρ does not depend on length, and area is proportional to l^2, we can say that $l^2v^2 \propto l^3$, hence $v^2 \propto l$ or $v \propto l^{1/2}$.

Returing to $P = Fv$, we can now write $P \propto l^3 . l^{1/2} \propto l^{3.5}$. Hence if in all dimensions l becomes (1/2) l, the power needed goes as $\left(\frac{1}{2}l\right)^{3.5} = \left(\frac{1}{2}\right)^{3.5} l^{3.5} = \left(\frac{1}{2}\right)^{3.5} P$ where P is the power for the full-sized helicopter.

14. (a) As both cylinders have the same weight, the helium cylinder contains more moles of gas than the nitrogen cylinder, since the molecular mass of helium is lower than that of nitrogen. Now, as $P \propto (nT/V)$, (this is given in words in the question) with V and T constant, the pressure in the helium cylinder must be a lot higher than that in the nitrogen cylinder. This indicates that the helium balloon will fill faster, because the rate will be dominated by the pressure difference between the inside of the cylinder and the inside of the balloon. Both balloons are filled with the same number of moles of gas, n.

(b) Again using the relation $PV \propto nT$, this time with n and T the same for both balloons, the product of pressure and volume must be the same for the two balloons. As the balloons are identical, the volume of both balloons will be the same.

An important property of an ideal gas, and indeed of many other systems in physics, is the number of degrees of freedom which the system possesses. Each degree of freedom corresponds to one possible way in which the gas can store energy. Molecules can store energy through translation (linear motion), in three different directions, and in rotation. Monoatomic gases cannot store energy in rotation as they are point-like. Diatomic gases can store energy by rotating in two different rotational directons.

We are going to heat the balloons, but not very much, and so we shall assume that the pressure of the gas inside both balloons is constant. The molar heat capacity, that is the amount of heat required to raise the temperature of one mole of gas by one kelvin, of an ideal gas at constant pressure is given by

$$C_P = \left(\frac{f+2}{2}\right)R,$$

where f is the number of degrees of freedom of the gas and R is the universal gas constant.

The two balloons are now heated by supplying the same quantity H of heat (thermal energy) to each.

(c) From the words in the question, we have the equation, $H = nC_P\Delta T$, where ΔT is the difference between the initial and final temperatures, H the heat added, n the number of moles of gas and C_P the heat capacity at constant pressure. Rearranging for ΔT

$$\Delta T = \frac{H}{nC_P} = \frac{H}{nR\frac{f+2}{2}}.$$

As H, n and R are constants, only f is different for the two gases; $f = 3$ for helium (no rotational energy), and $f = 5$ for nitrogen (two degrees of rotation). This gives the following equations for ΔT

$$\Delta T_{He} = \frac{2H}{5nR} \quad \text{and} \quad \Delta T_{N_2} = \frac{2H}{7nR}$$

and so $T_{\text{final, He}} = T + \frac{2H}{5nR}$ and $T_{\text{final, }N_2} = T + \frac{2H}{7nR}$.

(d) The first step here is to calculate the volume increase for each balloon, then to take the difference between them. We are assuming that the pressure is constant, and we know that the number of moles is constant, so using the earlier relationship $PV = nRT$, the initial and final volumes are

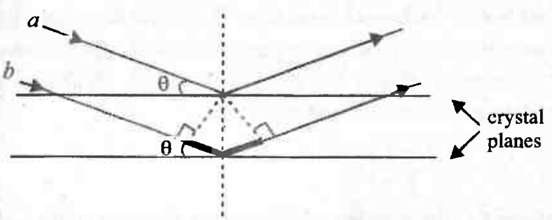
$$V_f = \frac{2nRT_f}{P} \quad \text{and} \quad V_i = \frac{nRT_i}{P}$$

and so $\Delta V = \frac{nR\Delta T}{P} = \frac{2H}{P(f+2)}$

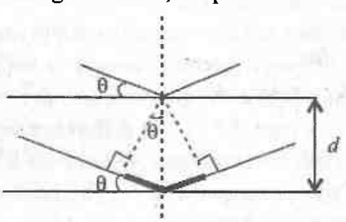
So finally, using $f = 3$ for He and $f = 5$ for N_2

$$V_{f,He} - V_{f,N_2} = \frac{2H}{5P} - \frac{2H}{7P} = \frac{4H}{35P}.$$

15. (a) See diagram. The dark section is the path difference, the extra distance ray b must travel compared to ray a. Note that the X-rays that come in and go out are parallel, and effectively meet at infinity. As crystal spacings are usually on the scale of 10^{-9} m, "infinity" can be a few cm away, which is where the source and detector are.



(b) Using the diagram below, the path difference = $2d\sin\theta$.



(c) The condition for constructive interference is that the path length difference is equal to an integer number of wavelengths, so that all the waves interfere constructively.

Hence we required path difference,

$2d\sin\theta = m\lambda$, where $m = 1, 2, 3, ...$

(d) Take the above formula and rearrange to obtain $\sin\theta = \frac{m\lambda}{2d}$,

For $m = 1$: $\sin\theta = \frac{m\lambda}{2d} = \frac{1.54 \times 10^{-10}\text{ m}}{2 \times 5.5 \times 10^{-10}\text{ m}} = 0.14$

and hence $\theta = 8.0°$.

For $m = 2$: $\sin\theta = \frac{m\lambda}{2d} = 0.28$ and hence $\theta = 16°$.

(e) See diagram for part (b). The difference is that wavelength is now $\lambda = \lambda_{air}/n_{oil}$ where λ is the wavelength in oil and λ_{air} is the wavelength in air of the X-rays, so the incident angle will be given by

$2d\sin\theta = m\lambda_{air}/n_{oil}$.

(f) See diagram below. For constructive interference in the oil the condition on the path difference becomes

path difference = $2d\sin\theta = m\lambda = m\lambda_{air}/n_{oil}$

where λ is the wavelength in oil and λ_{air} is the wavelength in air of the X-rays, and θ is the angle of incidence to the surface in oil.

We are trying to find, $d = \frac{m\lambda}{2\sin\theta} = \frac{m\lambda_{air}}{2n_{oil}\sin\theta}$.

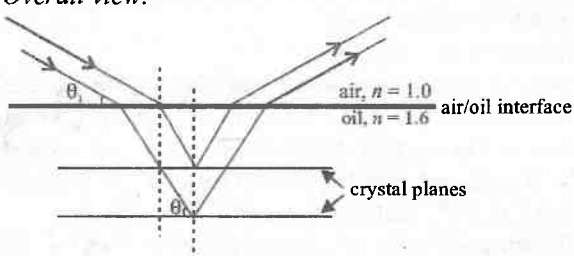
We have numbers for everything in this expression except the angle θ, which we can work out using Snell's law $n_1\sin\theta_1 = n_2\sin\theta_2$.

See diagram below. The angle θ is 52°.

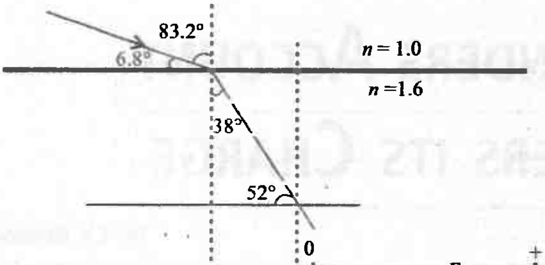
Putting the numbers in, with $m = 1$ for the smallest angle, gives:

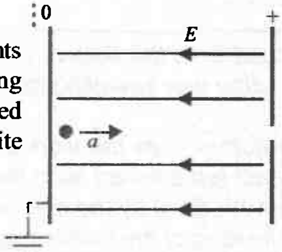
$$d = \frac{m\lambda}{2\sin\theta} = \frac{m\lambda_{air}}{2n_{oil}\sin\theta} = \frac{1 \times 1.54 \times 10^{-10}}{2 \times 1.6 \times \sin(52°)}$$
$$= 0.61 \times 10^{-10}\text{ m.}$$

Overall view:



Close view for finding angles:



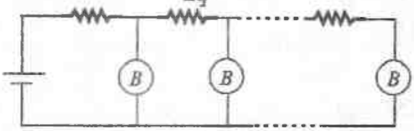


16. (a) The electric field points in the direction of decreasing potential. Negatively charged balls will move in the opposite direction to the electric field.

(b) The energy gained by a charge moving through an electric field is equal to the charge times the negative of the potential difference between the initial and final points: $-q\Delta V$.

In this case, we get energy = qV. Now this energy is converted into kinetic energy, which gives $qV = \frac{1}{2}mv^2$, where m and v are defined in the problem. Solving for V, the minimum potential that needs to be applied for velocity v gives $V = \frac{1}{2q}mv^2$

(c)



(d) Each machine draws a current i. Thus, with N machines, and since all of the current flows through the first resistor, the total current flowing through the first resistor is Ni.

(e) Using Ohm's law, $V = IR$, the potential difference across the first resistor is Nir. The potential applied to the first device in the chain is hence $V - Nir$.

(f) At the second resistor, there is a current $(N-1)i$ flowing through the resistor. Thus, the potential drop over the second device is $(N-1)ir$, and so the potential applied to the second device is $V - Nir - (N-1)ir$. By the time that we reach the last device in the chain, the potential applied is

$$V - ir\sum_{n=1}^{N} n.$$

Using the hint given, this can be written as

$$V \quad \frac{irN(N+1)}{2}.$$

(g) The last device in the chain needs a voltage of at least $mv^2/2q$ to shoot the ball properly.

Hence, $V - \frac{irN(N+1)}{2} > \frac{mv^2}{2q}$.

This can be rearranged to give a quadratic equation for N.

$$N^2 + N - \frac{2V}{ir} + \frac{mv^2}{irq} \le 0.$$

Solving for N (and taking only the positive solutions as the negative is unphysical) gives

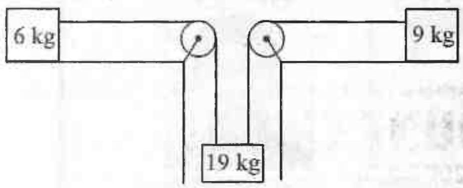
$$N = \left[\frac{-1 + \sqrt{1 + 4\left(\frac{2V}{ir} - \frac{mv^2}{irq}\right)}}{2}\right]$$

Mathematical hint : $\sum_{i=1}^{n} i = \frac{1}{2}n(n+1)$. ◆

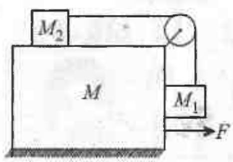
Thought Provoking Problems in Dynamics

By : Prof. R.S. Randhawa*

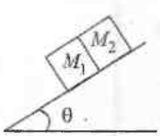
1. In the system shown in the figure, all the surfaces are smooth. The 19 kg block is prevented from rotating, i.e. comes straight down. Find its acceleration and tension in each cord.



2. In the system shown in the figure, the block M_1 is being prevented from descending by pulling M to the right with force F. Assuming all the surfaces to be frictionless, find F.



3. Two blocks are kept on an incline in contact with each other. Masses of blocks are M_1 and M_2 and coefficient of friction are μ_1 and μ_2 respectively. The angle of inclination is θ. Find (i) acceleration of blocks (ii) force R with which the blocks press against each other.

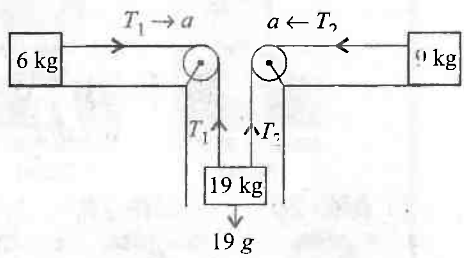


4. Assuming the lengths of the chain to be L and coefficient of static friction μ. compute the maximum length of the chain which can be held outside a table without sliding.

5. If the coefficient of friction between an insect and bowl is μ and the radius of the bowl is r, find the maximum height to which the insect can crawl up in the bowl.

SOLUTIONS

1. From free body diagram of 6 kg, 9 kg and 19 kg. Equations of motion are given by



$T_1 = 6a$ .... (i) and $T_2 = 9a$ ..... (ii)

$19g - (T_1 + T_2) = 19a$ .....(iii)

Adding up (i), (ii) and (ii), we get, $34a = 19g$

$\therefore \ a = \frac{19}{34} g \text{ ms}^{-2}$

Put a in (i) and (ii), we get, $T_1 = \frac{57}{17}$ N and $T_2 = \frac{171}{34}$ N

2. Free body diagram is given by,

Equation of motion of block M_2

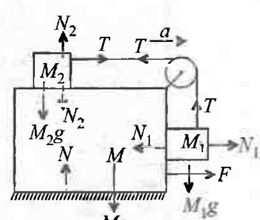
$T = M_2 a$ ..... (i)

$N_2 = M_2 g$ ... (ii)

Equation of motion of block M_1;

$T = M_1 g$ ..... (iii)

$N_1 = M_1 a$ ...... (iv)



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Now equation of motion of block M, using free body diagram,

$F - T = Ma + N_1$ .... (v)

$N = N_2 + M_1 g + T$ .... (vi)

Equating (i) and (iii), we get $M_1 g = M_2 a \Rightarrow a = \left(\frac{M_1}{M_2}\right) g$

Put a in (iv)

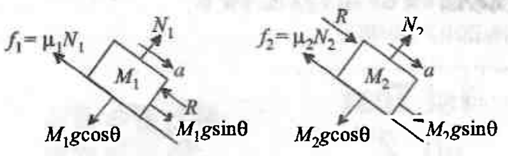
$$N_1 = M_1\left(\frac{M_1}{M_2}\right) g \text{ or } N_1 = \frac{M_1^2 g}{M_2}$$

From equation (v) $F - T = M\left(\frac{M_1}{M_2}\right) g + N_1$

Using N_1, and $T = M_1 g$, we get

$$F = M_1 g + \frac{MM_1}{M_2} g + \frac{M_1^2 g}{M_2} = M_1 g \frac{[M + M_1 + M_2]}{M_2}$$

3.



Free body diagram of M_1 Free body diagram of M_2

Equations of motion of free body diagram of M_1

$\sum F_x = M_1 g\sin\theta - R - \mu_1 N_1 = M_1 a$ .... (i)

$\sum F_y = N_1 - M_1 g\cos\theta = 0$ ..... (ii)

Now, equations of motion of free body diagram of M_2

$\sum F_x = M_2 g\sin\theta + R - \mu_2 N_2 = M_2 a$ ... (iii)

$\sum F_y = N_2 - M_2 g\cos\theta = 0$ .... (iv)

Now, add up N_1 and N_2 from equations (ii) and (iv) in equations (i) and (iv) we get,

$$a = \frac{(M_1 + M_2) g\sin\theta - (\mu_1 M_1 + \mu_2 M_2) g\cos\theta}{M_1 + M_2}$$

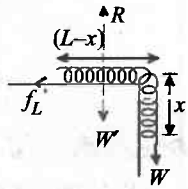
Also from equation (i), we get,

$$R = \frac{(\mu_2 - \mu_1) M_1 M_2 g\cos\theta}{M_1 + M_2}$$

If $\mu_1 > \mu_2$, then R becomes negative, which is not possible, which also means that blocks will separate.

4. Since $W = f_L$ .... (i)

From figure $W = \frac{M}{L} xg$ and $R = W' = \frac{M}{L}(L - x) g$



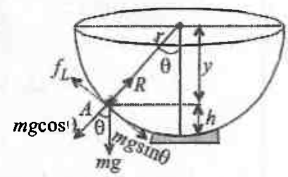
Then $f_L = \mu R = \mu \frac{M}{L}(L - x) g$

put the values of W and f_L in equation (i), we get

$$\frac{M}{L} xg = \mu \frac{M}{L}(L - x) g$$

which gives $x = \frac{\mu L}{(1 + \mu)}$

5. From figure



$R = mg\cos\theta$ ..... (i)

$f_L = mg\sin\theta$ ..... (ii)

Dividing equation (ii) by (i)

$\tan\theta = \frac{f_L}{R}$ or $\tan\theta = \mu \; [\because f_L = \mu R]$

or $\frac{\sqrt{r^2 - y^2}}{y} = \mu \Rightarrow y = \frac{r}{\sqrt{1 + \mu^2}}$

$$\therefore h = r - y = r\left[1 - \frac{1}{\sqrt{1 + \mu^2}}\right]$$

Train *Your* Brain

This exercise will give your brain the workout it needs!

Australian Physics Olympiad Problems

SECTION - A

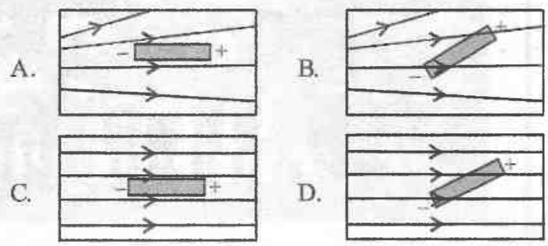
Multiple Choice Questions with one correct answer

1. A point particle is at equilibrium when the net force on it is zero. Which of the following statements is/are correct?
(a) Any object in equilibrium is at rest
(b) An object in equilibrium is not necessarily at rest
(c) An object at rest must be in equilibrium
(d) Both (b) and (c)
(e) None of the above

2. A 100 kg skier starts from rest on top of a snowy hill 30 m above a [illegible]ntal patch of gravel, and skis down the hill into the [illegible]. Assuming that the snow and air are frictionless, and that the skier's coefficient of friction with the gravel is 0.75, how far will the skier slide on the gravel before coming to a stop?
(a) 400 m (b) 90 m (c) 900 m
(d) 4 m (e) 40 m.

3. A large truck and a small car collide and stick together. Which one undergoes the larger change in momentum?
(a) The car (b) The truck
(c) The momentum change is the same for both vehicles
(d) You can't tell without knowing the final velocity of the combined masses.
(e) The result depends on the energy absorbed by the crumpling bodies of the vehicles on impact.

4. An electric dipole with no net charge consisting of a positive charge bound to a negative charge separated by a small distance as shown in the figure below is placed in an external electric field. In the diagrams, the lines with arrows are electric field lines and the arrows indicate the direction of the electric field. In which situation is the net force on the dipole zero?



(a) A only (b) C only
(c) A and C (d) D only
(e) C and D

5. An aeroplane must accelerate to a minimum speed before it can take off. At this speed, the change in momentum of the air directed downward by the wing per second is equal to the gravitational force acting on the plane. The density of air decreases with increasing humidity. Which of the following statements is true?
(a) On a humid day, the minimum take off speed is greater because the air density is lower.
(b) On a humid day, the minimum take off speed is lower because the water condenses on the surface of the aircraft, reducing its coefficient of drag.
(c) The minimum take off speed is the same on a humid day as on a dry day.
(d) On a dry day, the minimum take off speed is greater because the air density is greater.
(e) On a dry day, the minimum take off speed is lower because there is no condensation and so the plane's mass is lower.

6. A superhero standing on the ground (because her rocket pack is at the cleaner's) catches a 60 kg man falling from a height of 80 m above the ground. Assuming she has unlimited strength and can catch the man when he is 3 m above the ground(she has very long arms). Which of the following is closest to the minimum constant force she has to apply to the man to just stop him from reaching the ground? (Ignore air resistance.)

(a) 16000 N (b) 3600 N
(c) 1600 N (d) 1440 N
(e) 14400 N.

7. Two radio stations that are 250 m apart emit radio waves of wavelength 100 m. Point *A* is 400 m from both stations. Point *B* is 450 m from both stations. Point *C* is 400 m from one station and 450 m from the other. The radio stations emit in phase. Which of the following statements is true?
(a) There will be constructive interference at *A* and *B*, and destructive interference at *C*.
(b) There will be destructive interference at *A* and *B*, and constructive interference at *C*.
(c) There will be constructive interference at *A*, and destructive interference at *B* and *C*.
(d) There will be constructive interference at *B* and *C*, and destructive interference at *A*.
(e) There will be destructive interference at *A*, *B* and *C*.

8. A guitar string is tuned to a particular pitch by changing the tension in the string while it is fixed at the ends. If a tuned guitar was (unwisely, perhaps) played underwater, which of the following statements is not always true?
(a) The wavelength of vibration of the string would be the same.
(b) The frequency of the vibration of the string would be reduced by the water resistance.
(c) The frequency of the sound in the water would be the same as the vibrating frequency of the string.
(d) The sound would travel faster in the water.
(e) The wavelength of the sound in the water would be the same as the wavelength of the vibrating string.

9. A possum is hanging by its tail in the back of a truck. The truck is decelerating at a constant rate on a horizontal road and the possum is hanging at an angle of 35° to the vertical. Which of the following is closest to the deceleration of the truck?
(a) 5.6 ms^{-2} (b) 6.9 ms^{-2}
(c) 8.0 ms^{-2} (d) 14 ms^{-2}
(e) Can't be determined from the information given.

10. A mass *m* undergoing circular motion close to the earth's surface. The speed of the mass is constant. Considering only the information given and making no further assumptions about the system, which of the following statements is definitely true?
(a) The acceleration of the mass is zero because its speed is constant.
(b) The force on the mass is directed radially outward away from the centre of circular motion.
(c) The force on the mass is directed radially outwards. The acceleration is radially inwards towards the centre of circular motion.
(d) The energy of the mass is constant.
(e) Both the net force and net acceleration are radially inwards.

11. An object hangs motionless from a spring. When the object is pulled down, the sum of the elastic potential energy of the spring and the gravitational potential energy of the object and Earth.
(a) increases (b) decreases
(c) stays the same
(d) can either increase or decrease depending on the spring constant.
(e) can either increase or decrease depending on the mass of the object.

12. A ball, thrown from a tall building, reaches terminal velocity. If the action is the force of gravity on the ball, what is the reaction from Newton's third law?
(a) The force of air resistance on the ball.
(b) The acceleration of the ball.
(c) The pull of the ball's mass on the Earth.
(d) The force of the ball on the air.
(e) There is no force of gravity as the ball is not accelerating.

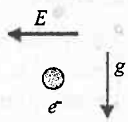
13. A laser beam and a sound wave from directional sources both enter a liquid at an angle of 60° from the horizontal surface of the liquid. The speed of sound in the liquid is 1.8 times that of the speed of sound in air. For light, the refractive index of the liquid is 1.8. What happens?
(a) The light refracts to an angle of 74° from the horizontal, and the sound passes straight through.
(b) Both the light and the sound refract at an angle of 74° from the horizontal.
(c) The light refracts to an angle of 26° from the horizontal and the sound refracts to an angle of 74° from the horizontal.
(d) The light refracts to an angle of 26° from the horizontal and the sound reflects completely off the surface.
(e) The light refracts to an angle of 74° from the horizontal and the sound refracts to an angle of 26° from the horizontal.

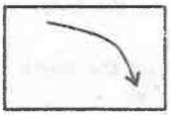
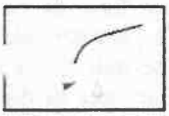
14. A soap bubble (made of clear soap) falling at a constant rate in the earth's atmosphere is observed

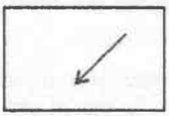
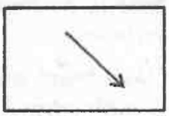
by a student looking at light reflecting off the surface of the bubble. Under illumination by white light the bubble is observed to have colours that move on its surface as the soap film slowly flows. Over time, the top of the soap bubble thins as the soap film flows slowly under gravity to the bottom of the bubble. When the top of the film is 200 nm thick, it is observed to be yellow, showing that destructive interference is occurring for blue light (i.e. 400 nm). As the thickness at the top of the bubble approaches zero, the colour observed at the top of the bubble approaches

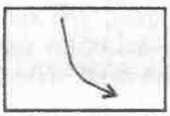
(a) yellow (b) white (c) blue
(d) green (e) black.

15. An electron is placed, initially at rest, in a constant, uniform gravitational field and a constant, uniform electric field as shown in the diagram. What, qualitatively, is the shape of the trajectory of the electron?

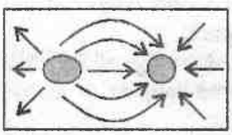
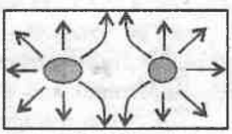


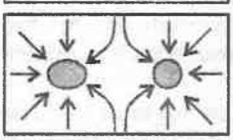
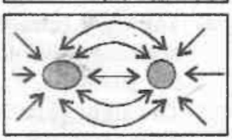
(a)  (b) 

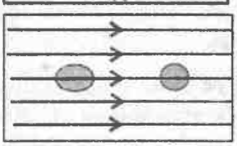
(c)  (d) 

(e) 

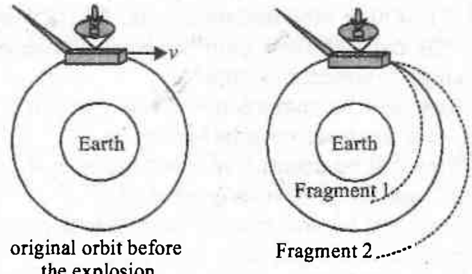
16. Which of the following diagrams correctly the gravitational field lines for a pair of masses?

(a)  (b) 

(c)  (d) 

(e) 

17. A satellite is in a circular orbit around Earth. Due to an electrical fault, the satellite explodes and breaks into two parts of equal mass. The velocities of the two fragments are in the same direction as before the explosion, however one fragment has a greater velocity than the other.



original orbit before the explosion

orbits after the explosion

Given the following five statements:

(i) The fragment with the greater velocity goes into the higher orbit.

(ii) The fragment with the lower velocity goes into the higher orbit.

At the point of the fragment's orbits opposite the explosion:

(iii) Fragment 1 has a lower velocity than it had immediately after the explosion and fragment 2 has a greater velocity than it had immediately after the explosion.

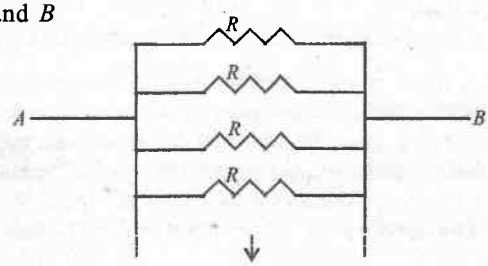
(iv) Fragment 1 has a greater velocity than it had immediately after the explosion and fragment 2 has a lower velocity than it had immediately before the explosion.

(v) The two fragments have the same velocity at this point as their respective velocities immediately after the collision.

Which of the following is true?

(a) (i) and (iii) (b) (i) and (iv)
(c) (ii) and (iii) (d) (ii) and (iv)
(e) (i) and (v)

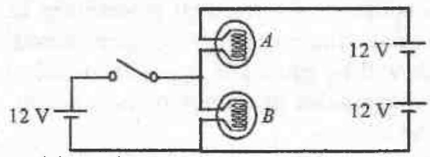
18. The diagram below shows a parallel circuit, in which the wires have no resistance. As more identical resistors are added to the circuit, the resistance between A and B



(a) increases and approaches a finite value
(b) increases and approaches infinity
(c) decreases and approaches zero
(d) decreases and approaches a non-zero value
(e) remains the same.

19. Two light bulbs, each of which would consume 100 W when connected to a certain constant voltage power supply are now connected to the same supply in series. What is the total power consumed?
(a) 50 W (b) 100 W
(c) 200 W (d) 400 W
(e) Not enough information is given.

20. The light bulbs A and B in the following circuit are identical. When the switch is closed



(a) nothing changes
(b) the intensity of bulb A increases
(c) the intensity of bulb A decreases
(d) the intensity of bulb B increases
(e) the intensity of bulb B decreases

SECTION - B

Short Answer Questions

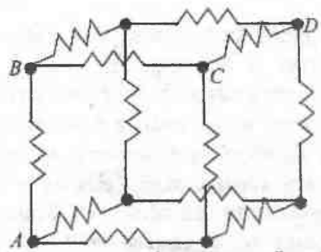
21. Alix, who has a mass of 50 kg, slides from rest down a banister (hand rail) of a flight of stairs. The banister is 4.0 m long and at an angle of 30° to the horizontal and the coefficient of friction between Alix's clothes and the banister is 0.50.
(i) Draw a diagram showing all the forces acting on Alix as she slides down the banister.
(ii) List all the forces that do work in this process.
(iii) Describe the energy transfers (noting the forces causing them) that take place as Alix slides down the banister.
(iv) Find Alix's speed as she reaches the end of the banister.
(v) Find the average rate at which energy is dissipated as heat as Alix slides down the banister.

22. A student has measured the elastic potential energy stored in a spring as a function of the extension of the spring. The set of data is given in the table below. $U = \frac{1}{2}k(\Delta x)^2$ where U is the potential energy, Δx is the extension, and k is known as the spring constant. Hint: it is easier to get information from a straight line graph than from anything else, so you should think about what you should plot.
(i) Plot an appropriate graph and label your axes, include units and an appropriate title.
(ii) Find the spring constant by measuring appropriate quantities from the graph. Give the spring constant in SI units (kg s^{-2}).
(iii) Comment on any other features of your graph and what physical meaning they may have.

Data :

$U(x)$(J)	0.023	0.020	0.036	0.056	0.067	0.085	0.111
Δx(cm)	−1.0	1.0	2.0	2.5	3.0	3.5	4.0

23. Twelve resistors are arranged into a cube as shown in the figure below. All resistors have a resistance of 6 Ω. A 25 V potential difference is applied from point A to point D.



(i) Where $i_{M \to N}$ means the current flowing from the point M to the point N, use symmetry arguments to find the relative sizes of $i_{A \to B}$, $i_{B \to C}$, $i_{C \to D}$ and the total current flowing from A to D.
(ii) Find the potential difference across each of these resistors.
(iii) Find the total resistance of the cube of resistors from point A to point D.

SECTION - C

Long Answer Questions

24. The classical Doppler shift is a well-known effect describing the change in observed frequency of a wave due to motion of the source or observer. In this question, you will investigate the causes of this effect.
(a) The relationship between the frequency f, wavelength λ and velocity v of a wave in a medium is given by $v = f\lambda$. Consider a situation in which an observer is travelling at a velocity v_o towards a source of waves, which is emitting a frequency f. In this case, the source is stationary with respect to the medium in which the wave travels.
(i) Draw a diagram of the situation, including a sketch

of the position of the crests of the emitted waves.

(ii) How many crests does the observer encounter during a time t? Note that at this point no actual numbers are required. Fractions of a crest indicate the proximity to the next crest.

(iii) Show that the frequency with which the observer encounters crests is given by $f' = f\dfrac{v+v_o}{v}$ where v is the velocity of the wave.

(b) The equation for the classical Doppler shift when both the source and observer are moving with respect to the medium is $f' = f\dfrac{v \pm v_o}{v \mp v_s}$, where the top sign in both the numerator and denominator corresponds to motion towards the other party. Note that this equation reduces to the formula derived in part a when the source is not moving with respect to the medium.

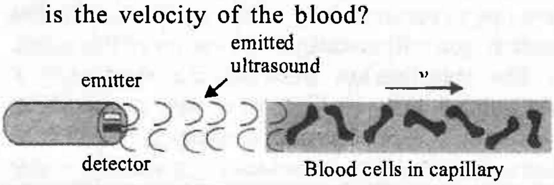
(i) What happens to the observed frequency when the observer is not moving?

(ii) Is the frequency observed when a source is moving with velocity u towards a stationary observer the same as when an observer is moving towards a stationary source with velocity u?

(iii) What happens to the observed frequency when the velocity of a source moving towards a stationary observer approaches the speed of sound? Explain your answer from a physical perspective.

(iv) What happens to the observed frequency when the velocity of the observer moving away from a stationary source approaches the speed of sound? Explain your answer from a physical perspective.

(c) The Doppler effect is used in hospitals to measure the rate of blood flow by bouncing ultrasound waves off red blood cells. If the blood cells are moving along a vein away from the transmitter, and the average frequency difference between the received and transmitted waves is 140Hz, what is the velocity of the blood?



ANSWERS

SECTION A

1. (b) : If the net force is zero, the body can be in static equilibrium or in a dynamic equilibrium. In the second case, acceleration is zero, velocity is a constant. (Newton's first law).

2. (e) : The potential energy Mgh of the skier is converted to kinetic energy at the bottom of the hill.

$$\therefore \quad Mgh = \frac{1}{2}Mv^2 \Rightarrow v^2 = 2gh = 2\times10\times30 = 600$$

This is initial velocity² on the ground. $v_{\text{final}} = 0$.

$$\therefore \quad v^2 - u^2 = -\frac{2\mu_k mg}{m}\cdot s \Rightarrow 0 - 600 = -2\times0.75\times10\times s$$

$$\therefore \quad s = \frac{-u^2}{-2\times0.75\times10} = +\frac{600}{2\times0.75\times10} = 40 \text{ m}.$$

3. (c) : The law of conservation of momentum is applied in collision. As the total momentum has to remain the same, whatever be the change in momentum of the truck will be equal and opposite to that of the car. Their magnitudes of change of momentum will be the same.

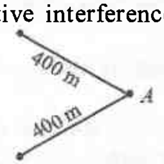
4. (e) : There will be a net force on a dipole together with a torque if the field is non-uniform. But in a uniform field, the net force is zero as the force Eq is the same for both $+q$ as well as $-q$, but there is no torque if the dipole is parallel to the field. In (D) one has no force but a torque. Therefore for (C) and (D) there is no force.

5. (a) : As humid air has less density, the upward thrust will be less, The speed for taking off is greater.

6. (a) : The kinetic energy on reaching the ground would have been equal to its maximum potential energy, $Mgh = 60 \times 10 \times 80$. This has to nullified by a force applied by the superwoman in 3 metre.

$$i.e., \; F\times3 = 60\times10\times80 \Rightarrow F = 16000 \text{ N}.$$

7. (a) : If the path difference is $n\lambda$, one will have constructive interference and if it is $(2n+1)\dfrac{\lambda}{2}$ one will have destructive interference.



Path difference is zero. ∴ It has constructive interference.

Same for B, 450 m − 450 m = 0.

$$\text{Path difference} = (450-400)\text{ m} = \frac{100}{2} = \frac{\lambda}{2}.$$

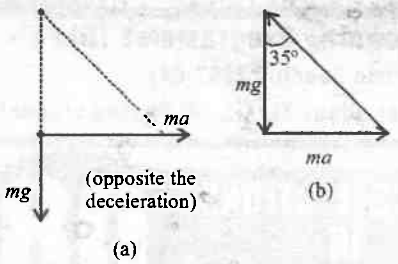
There is destructive interference.

8. (e) : For a given string, the wavelength is the same. The velocity, frequency and wavelength are fixed for a given string of the same tension and length. When waves pass from one medium to another, frequency is the same. But, as the velocity of waves in water is very high, the wavelength will be larger in liquid.

The effect of damping is to reduce amplitude of the waves produced by the string and if damping is not small, its frequency also will be reduced.

(e) is the statement which is not true always.

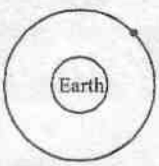
9. (b) :



$$\tan 35° = \frac{ma}{mg} \Rightarrow a = g\tan 35° = 10\tan 35° = 7.0\ \text{m/s}^2$$

$$\simeq 6.9\ \text{m/s}^2$$

10.



For circular motion taking the inertial frame, one takes centripetal force where one assumes the force and the acceleration is always acting towards the centre. As given by Resnick and Halliday[1], it is equally correct to take the reference frame of the body revolving round. In that case, at every instant, the centripetal force towards the centre is cancelled by the centrifugal force. Both are correct according to reference(1). However as the reason for continued rotation is the law of conservation of angular momentum, taking the centripetal and centrifugal force for the body is more logical[2].

(e) is the choice according to inertial frame but according to our choice.

(a) The net acceleration of the mass is zero. In uniform motion, neither tangential velocity nor angular velocity changes.

(b) is not correct. The outward and inward forces are acting on the body towards and away from the centre. The centrifugal force does not act on the centre but on the revolving body.

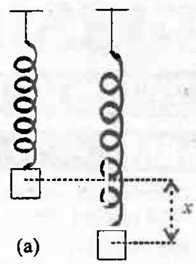
(c) is only partially correct.

This question is based on inertial frame, hence the text-book answers are given.

(1) Resnick, Haliday and Krane - Physics, V Edn. Vol.1.

(2) Krishnan, T.V., Beyond the Barriers (Extn. Lectures in Physics).

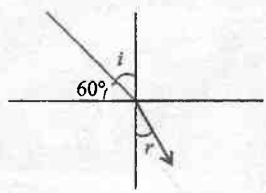
11. (a) :



Potential energy of the spring is $\frac{1}{2}kx^2$ The potential energy of the spring increases. The loss of potential energy by decrease in height is more than compensated by the spring. That is why it is pulled back.

12. While a ball that is falling down freely through a viscous medium or air, the earth is applying a force on the mass making it fall down, although the acceleration can be cancelled by the viscosity of the air. But to say that an equal force is acting on the earth by the mass may not be exact. Certain conditions have to be satisfied before action is equal to reaction.

13. (e) : $\mu = \frac{\sin i}{\sin r} = \frac{\text{velocity of wave in air}}{\text{velocity of wave in the medium}}$



i is the angle of incidence, 30° (as $i = 90 - 60°$).

μ = 1.8 for light.

$$\frac{\sin 30°}{\sin r} = 1.8$$

Speed of sound in liquid is 1.8 times that in air.

$$\therefore \mu_{\text{liquid}} = \frac{v_{air}}{1.8v_{air}} = \frac{1}{1.8} < 1. \therefore\ r > i.$$

90° – 26° = 64° · with the horizontal, 26° is for sound wave.

90° – 74° = 16° · and 74° for light.

14. (e) : When the path difference due to the soap film is zero, the phase difference due to reflection is $\pi/2$. There is destructive interference.

15. (d) : Both electric and gravitational fields accelerate the electron. the acceleration due to the electric field is opposite the direction of the field because the electron

is negatively charged.

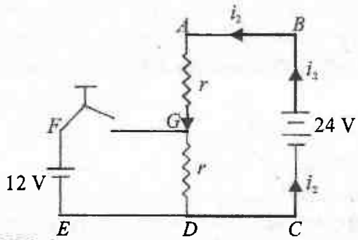
16. (c) : The field lines show the direction of force on a small test mass. The gravitational force is attractive hence for masses, gravitational field lines always point in towards the mass.

17. (b) : This is an application of energy for orbits (or Kepler's laws) and conservation of momentum.

18. (c) : Resistors in parallel give multiple paths for current, hence adding more resistors in parallel gives a decreasing total resistance.

19. (a) : When the bulbs are connected in series only the half the current flows as compared to the current through each bulb when they are connected either in parallel or individually. Power is proportional to current, hence the power is 1/2 that a single bulb.

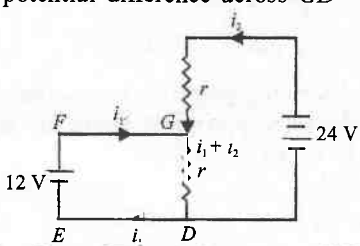
20. (a) :



Loop $ABCDA$

$i_2r + i_2r = 24$ V

$\Rightarrow$ potential difference across GD = 12 V.

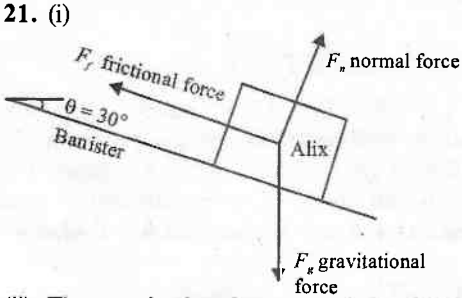


Taking loop $GDEF$, $-(i_1 + i_2)r + 12\text{ V} = 0$

$\Rightarrow$ $(i_1 + i_2)r = 12$ V.

$\therefore$ Across GD there is no change.

21. (i)



(ii) The gravitational force and the frictional force do work in this process. (The work done by one is negative relative to the other).

(iii) At the top of the banister Alix is at rest and so has only gravitational potential energy. As she slides down the banister, this is converted into kinetic energy by the gravitational force. Some of this kinetic energy is converted into heat energy by the frictional force.

(iv) Let m = Alix's mass, a = Alix's acceleration, u = Alix's initial velocity, v = Alix's final velocity, F_x = force parallel to banister, g = acceleration due to gravity, μ_k = coefficient of friction, R = rate of energy dissipation, W_f = work done by frictional force, t = time taken down banister

$$\sum F_x = ma$$
$$(F_g)_x - F_f = ma$$
$$mg\sin\theta - \mu_k F_n = ma$$
$$mg\sin\theta - \mu_k mg\cos\theta = ma$$

Hence, $a = g(\sin\theta - \mu_k\cos\theta)$ or $a = 0.66\text{ ms}^{-2}$.

Using the standard kinematics equation;

$$v^2 = u^2 + 2as \quad \text{or} \quad v = \sqrt{2gs(\sin\theta - \mu_k\cos\theta)}$$

$\therefore$ $v = 2.3$ m/s.

(v) Total energy lost as heat = work done by frictional force

$$R = \frac{W_f}{t}$$

$W_f = F_f s$; $W_f = \mu_k mgs\cos\theta$

$W_f = 850$ J.

Using standard kinematics equation;

$$s = ut + \frac{1}{2}at^2 \quad \text{or} \quad t = \sqrt{\frac{2s}{a}}$$

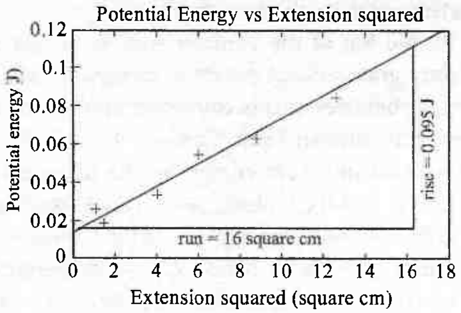
or $t = \sqrt{\dfrac{2s}{g(\sin\theta - \mu_k\cos\theta)}} = 3.48$ s.

Therefore, $R = mgs(\sin\theta - \mu_k\cos\theta)\dfrac{\sqrt{g(\sin\theta - \mu_k\cos\theta)}}{\sqrt{2s}}$

or, $R = m\sqrt{\dfrac{s}{2}}\,[g(\sin\theta - \mu_k\cos\theta)]^{\frac{3}{2}} = 38$ W.

(**Note :** as the equation did not specify time rate of energy dissipation, *i.e.* power, answers in terms of rate per unit distance travelled were also accepted where correct).

22. (i) An appropriate graph in this case is U vs $(\Delta x)^2$, from which the gradient can be found, and the k can be found from the gradient. (The question also gave the hint that a straight line graph is a good idea). A graph of U vs x gives a parabola, which is not a useful curve for finding k.



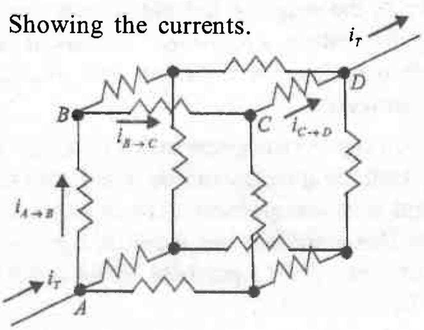
(ii) The slope is $m = \frac{1}{2}k$. The slope may be measured from the graph by measuring the rise over the run of the line of best fit. This is shown in the graph.

Now, $k = 2\,\dfrac{\text{rise}}{\text{run}}$

From the graph rise = 0.095 J and run = 16 cm^2, these values give $k = 1.2 \times 10^{-2}$ kgm^2 s^{-2} cm^{-2}.
After converting to S.I. units, remembering 1 m = 100 cm, the value for the spring constant is found to be
$k = 1.2 \times 10^2$ kg s^{-2}.

(iii) The other features of note are the fact that the line of best fit does not pass through the origin and the points and scattered with the two points at $(\Delta x)^2 = 1$ not measured to have the same potential energy.
The reason for the line of best fit not passing through the origin it that for some reason the potential energy of the spring was not measured to be zero when it was zero. This is an example of a systematic error in data. It is not a real effect in this case.
The second feature to note is that the points are scattered about the line, and also that the two points at $(\Delta x)^2 = 1$ were not measured to have the same potential energy. The explanation of this is random errors in the measurements. This can be used to get an estimate of the uncertainty in the slope and so the uncertainty in the value of the spring constant measured.

23. (i) Showing the currents.



We first note that by symmetry, the current i_T into the node A must split evenly down the three identical paths, so we have $i_{A\to B} = \frac{1}{3}i_T$.

Next we see that B, the current again splits down the two identical pathways, so we have

$$i_{B\to C} = \frac{1}{2}i_{A\to B} = \frac{1}{6}i_T$$

We note that by conservation of current/Kirchhoff's junction law the total current in is the same as the total current out, and so by similar reasoning to that for node A, the three currents coming into node D must sum to i_T, giving us that $i_{C\to D} = \frac{1}{3}i_T$

Finally, using the relationships we have derived, we have that $i_T = 3i_{A\to B} = 6i_{B\to C} = 3i_{C\to D}$ which gives the relative sizes of the currents as required.

(ii) We shall first consider Ohm's law which tells us that

$$V_{A\to B} = i_{A\to B}R_{A\to B}$$
$$V_{B\to C} = i_{B\to C}R_{B\to C}$$
$$V_C = i_{C\to D}R_{C\to D}$$

In addition we see that since all resistors have the same value R, and using the results from the previous part of the question, all of the potentials can be written in terms of $V_{A\to B}$ as follows.

$$V_{B\to C} = \frac{1}{2}V_{A\to B} \text{ and } V_{C\to D} = V_{A\to B}$$

Now since we know the potential across the entire structure, and the three potentials above are across a path from A to D, we must have

$$V_T = V_{A\to B} + V_{B\to C} + V_{C\to D}$$

Combining the results

$$V_T = V_{A\to B} + \frac{1}{2}V_{A\to B} + V_{A\to B}$$

So we have $V_T = \frac{5}{2}V_{A\to B}$

Now, $V_T = 25$ V and so 25 V $= \frac{5}{2}V_{A\to B}$

Hence $V_{A\to B} = 10$ V, $V_{B\to C} = 5$ V and $V_{C\to D} = 10$ V.

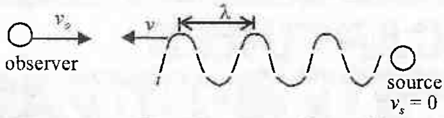
(iii) To find the total resistance, we once again appeal to Ohm's law to get $V_T = i_T R_T$. All that remains is to find the total current. Here we exploit results from part (i) and (ii) and use the fact that $R = 6\ \Omega$.

$$V_{A\to B} = \frac{1}{3}i_T R$$

Hence, 10 V $= \frac{1}{3}i_T \times 6\,\Omega \Rightarrow i_T = \frac{1}{2}\times 10\text{ A} = 5\text{ A}.$

and finally $R_T = \frac{V_T}{i_T} = \frac{25\text{ V}}{5\text{ A}} = 5\ \Omega.$

SECTION C

24. (a) (i) 

(ii) In a time t the observer travels a distance $x_o = v_o t$, and any given wave crest travels a distance $x = vt$, so relative to any given crest the distance travelled is $x + x_o = (v_o + v)t$.

The number of wavelengths encountered in this time is

$$\frac{x_o + x}{\lambda} = \frac{(v_o + v)t}{\lambda}.$$

(iii) The observed frequency is the number of crests per unit time, $f' = \frac{(v_o + v)t}{\lambda t} = \frac{(v_o + v)}{\lambda}$ and putting in $\lambda = v/f$, we get $f' = \frac{f\,(v_o + v)}{v}$.

(b) (i) Using $f' = f\frac{v + v_o}{v \mp v_s}$

When $v_o \to 0$, $f' = f\frac{v}{v \mp v_s}$

and any frequency shift is due only to the source velocity.

(ii) Source moving at $v_s = u$: $f' = f\frac{v}{v - u}$

Observer moving at $v_o = u$: $f' = f\frac{v + u}{v}$

These are not the same (expect in limit as $u \to 0$), the shift is greater for a moving source.

(iii) If $v_s \to v$ and $v_o = 0$ and the motion is towards the observer, then the frequency gets very large, but at the limit $v_s \to v$, $f' = f\frac{v}{v - v} = \infty$ but in fact the frequency is zero because the source reaches the observer at the same time as the first crest, and if $v_s > v$ the sound is only heard after the source has passed. (You will also get bunching of the wavefronts resulting in sonic boom).

(iv) If $v_o \to v$ and $v_s = 0$ and the motion is away from the source, then the frequency gets very small, and is zero if $v_o = v$, if $v_o > v$ then the frequency is again heard low, and increases as the observer catches up and overtakes the crests.

(c) The frequency received by the cell is

$$f_{cell} = f\frac{v - v_{cell}}{v}$$

and then the received frequency with the cell acting as the source is $f_{rec} = f_{cell}\frac{v}{v + v_{cell}}$

So the received frequency related to the emitted frequency is $f_{rec} = f\frac{v - v_{cell}}{v + v_{cell}}$

We can relate this to the frequency difference:

$$\Delta f = f_{rec} - f = f\frac{v - v_{cell}}{v + v_{cell}} - f$$

and then some rearranging to get

$$\frac{\Delta f}{f} = \frac{v - v_{cell}}{v + v_{cell}} - 1 = \frac{-2v_{cell}}{v + v_{cell}}$$

So $\frac{\Delta f}{f}(v + v_{cell}) = -2v_{cell}$

$$\frac{\Delta f}{f}v = -2v_{cell} - \frac{\Delta f}{f}v_{cell}$$

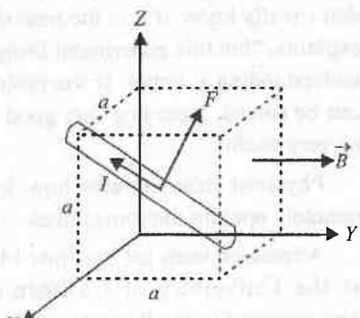
$$\frac{\Delta f}{f}v = \left(-2 - \frac{\Delta f}{f}\right)v_{cell}$$

and finally $v_{cell} = \frac{-\Delta f v}{2f + \Delta f}$. ■

Thought Provoking Problems in Magnetics

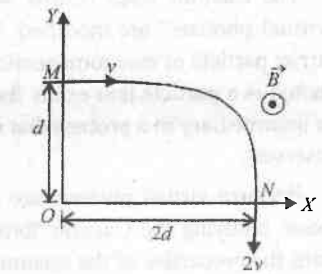
By : Prof. R.S. Randhawa*

1. A straight wire lies along a body diagonal of an imaginary cube of side $a = 40$ cm, and carries a current of 9 A. Find the force on it due to a uniform field $\vec{B} = 0.3\hat{j}$ T.

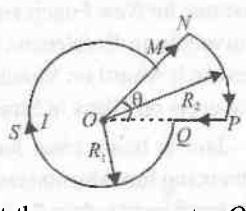


2. A rod has total charge Q uniformly distributed along its length L. If the rod rotates with the angular velocity ω about its ends, find its magnetic moment.

3. A particle of charge $+q$ and mass m moving in a uniform electric field $\vec{E} = E\hat{i}$ and a uniform magnetic field $B\hat{k}$ follows a trajectory as shown in figure. The velocity of particle at points M and N are $v\hat{i}$ and $-2v\hat{j}$ respectively and $ON = 2d$. Find (i) the magnitude of electric field E. (ii) The rate of work done by the electric field E at points M and N.



4. The current loop $MNPQSM$ formed by two circular segments of radii R_1 and R_2 carries a current I ampere.



(i) Find the magnetic field at the common centre O.

(ii) What will be the magnetic field if the angle $\theta = 90°$?

5. A hexagonal loop of a metallic wire is of each side l and carrying a current I. Find the magnitude of magnetic field at the centre of the loop.

SOLUTIONS

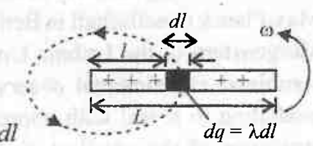
1. Since $\vec{F} = I\vec{l} \times \vec{B}$, we have $\vec{l} = a\hat{i} - a\hat{j} + a\hat{k}$ where a is the projection of the length in the three directions.

$\therefore \quad \vec{F} = IBa\,(\hat{i} - \hat{j} + \hat{k}) \times (\hat{j}) = (\hat{k} - \hat{i})IBa$

$\therefore$ The magnitude of force in the y-z plane,

$$F = \sqrt{2}\,IBa \quad \text{or} \quad F = \sqrt{2} \times 9 \times 0.3 \times 0.4 = 1.53 \text{ N}.$$

2. The current dI due to rotation of the charge is



$$dI = \frac{dq}{T} = \frac{dq}{2\pi/\omega} = \frac{\omega}{2\pi} \cdot \lambda dl$$

The magnetic moment due to small element is

$$dM = dI(\text{area}) = \left(\frac{\omega}{2\pi}\lambda dl\right)\pi l^2 = \frac{\lambda\omega}{2} l^2 dl$$

$\therefore$ Total magnetic moment, $M = \dfrac{\lambda\omega}{2}\displaystyle\int_0^L l^2\,dl = \dfrac{\lambda\omega L^3}{6}$.

or, $M = \dfrac{Q\omega L^2}{6}$ (by using $\lambda = Q/L$)

3. (i) Using work energy theorem,

$$\frac{1}{2}m(2v)^2 - \frac{1}{2}mv^2 = W$$

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$\therefore \quad \frac{3}{2}mv^2 = (qE)(2d)$ or $E = \frac{3mv^2}{4qd}$

(ii) Now, rate of the work done by the electric field at $M = Fv$ ($\because \theta = 0°, \cos\theta = 1$)

$$= (qE) \times v = \frac{3mv^2}{4qd}.$$

Similarly, at point N, rate of work done by the electric field $= Fv\cos 90° = 0$.

4. (i) Total magnetic field at O due to part NP given by Biot-Savart's law as

$$B_1 = \frac{\mu_0 I(\sum dl)}{4\pi R_2^2}\sin 90° \quad (\text{using } \sum dl = \text{arc} = R_2\theta)$$

$$= \frac{\mu_0}{4\pi}\frac{I\theta}{R_2}$$

(perpendicular to plane and directed downwards)

Similarly, magnetic field at O due to segment MSQ is

$$B_2 = \frac{\mu_0}{4\pi}\frac{I(2\pi-\theta)}{R_1}$$

(perpendicular to plane and directed downwards)

Now, magnetic field due to segment MN and $PQ = 0$

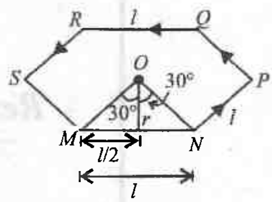
$\therefore$ Total magnetic field at O is $B = B_1 + B_2$

$$= \frac{\mu_0 I}{4\pi}\left[\frac{\theta}{R_2} + \frac{(2\pi-\theta)}{R_1}\right]$$

(Directed downward into the plane of paper)

(ii) If $\theta = 90° = \pi/2$, then $B = \frac{\mu_0 I}{8}\left[\frac{1}{R_2} + \frac{3}{R_1}\right]$.

5. Total magnetic field at O is $B = 6B'$ where B' = magnetic field at O due to each side of hexagonal is same.



$$B' = \frac{\mu_0 I}{4\pi r}[\sin 30° + \sin 30°]$$

(In ΔOMN, $r = \frac{\sqrt{3}}{2}l$, $\because \tan 30° = \frac{l/2}{r}$)

$$B' = \frac{\mu_0 I}{4\pi l}\frac{2}{\sqrt{3}} \times \frac{2}{2} = \frac{\mu_0 I}{2\pi l\sqrt{3}}$$

$$B = 6B' = 6 \times \frac{\mu_0 I}{2\pi l\sqrt{3}} = \sqrt{3}\left(\frac{\mu_0 I}{\pi l}\right).$$

■

Solved Paper

Bihar CECE (Mains) 2007

1. At what height above the earth's surface does the force of gravity decrease by 10%? The radius of earth is 6370 km.

2. A helicopter ascends with a velocity 10 m/s. At a height of 50 m, a heavy body is dropped from it. With what velocity does this body reach the ground?

3. An elastic spring whose length l_0 = 30 cm is compressed to l = 22 cm. Find the potential energy of the compressed spring if the force F = 0.5 MN/cm is required to reduce its length by unity.

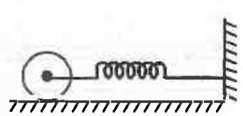
4. A stone attached to a rope of length l = 80 cm is rotated in a vertical plane with a speed 240 rpm. At the moment when the velocity of the stone is directed vertically upwards, the rope ruptures. To what height does the stone rise?

5. A balloon of volume 4000 m^3 is filled with helium of density 0.18 kg/m^3. The total mass of the balloon and equipment is 3 tonnes. At an altitude where the density of air is 1.2 kg/m^3, helium completely fills the balloon. Find the maximum mass of the load that can be lifted by the balloon.

6. A copper and a tungsten plates having a thickness of 2 mm each are joined together so that at 0°C they form a flat bimetallic plate. Find the average radius of curvature of this plate at 200°C. The coefficients of linear expansion for copper and tungsten are $1.7 \times 10^{-5}\ K^{-1}$ and $0.4 \times 10^{-5}\ K^{-1}$.

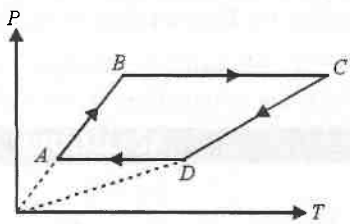
7. 10 g of ice is added in 40 g of water at 15°C. Calculate the temperature of the mixture.

8. A solid cylinder is attached to a horizontal massless spring so that it can roll without slipping along a horizontal surface. If the cylinder is slightly displaced and released, then find the time period of the simple harmonic motion.



9. A resonance tube is resonated with tuning fork of frequency 256 Hz. If the length of resonating air columns are 32 cm and 100 cm, then calculate the end correction.

10. 3 mole of an ideal monoatomic gas perform a cycle shown in figure. The gas temperature are T_A = 400 K, T_D = 1200 K. Find the work done by the gas.



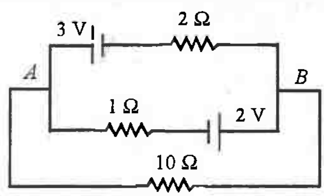
11. Find the speed of sound in a mixture of 1 mole of He and 2 mole of O_2 at 27°C.

12. A ring has charge Q and radius R. If a charge q is placed at its center, then calculate the increase in tension in the ring.

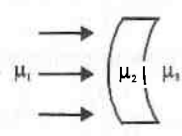
13. A resistance R = 1980 Ω is connected in series with a voltmeter after which the scale division becomes 100 times larger. Determine the resistance of the voltmeter.

14. Large number of capacitors of rating 10 μF, 200 V are available. Calculate the minimum number of capacitors to design a 10 μF, 700 V capacitor.

15. Calculate the current in 10 Ω resistance.



16. In the figure, light is incident on the thin lens as shown. Each surface has radius R. Find the focal length of the system in terms of μ_1, μ_2, μ_3 and R.



Contributed by : **Paradise Institute**, H.O. : Arya Kumar Road, Rajendra Nagar, Patna - 16

17. A Young's double slit experiment is performed using light of wavelength 500 nm, which emerges in phase from two slits a distance 3×10^{-5} cm apart. A transparent sheet of thickness 1.5×10^{-5} cm is placed over one of the slits. The refractive index of the material of this sheet is 1.17. Where does the central maximum of the interference pattern now appear?

18. The wavelength of the first line of Lyman series is 102 nm. Calculate the wavelength of H_α line of Balmer series.

19. A nucleus with mass number 220 initially emits α-particle. If the Q-value of the reaction is 5.5 MeV, calculate the kinetic energy of α-particle.

20. ^{208}Ra has half-life 120 days. Find the amount of ^{208}Ra if the activity level is one millicurie.

SOLUTIONS

1. Given $g' = g - \frac{10g}{100} = \frac{9}{10}g$

As for an external point earth behaves as whole of its mass is concentrated at the centre, *i.e.*, $g = \frac{GM}{r^2}$.

So at the surface of earth, $g = \frac{GM}{R^2}$ [as $r = R$]

And at the height h above the surface of earth,

$$g' = \frac{GM}{(R+h)^2} \quad [\text{As } r = R+h]$$

$$\therefore \quad \frac{g'}{g} = \frac{R^2}{(R+h)^2} \quad i.e., \; g' = \frac{g}{\left[1+\left(\frac{h}{R}\right)\right]^2} \quad \ldots (1)$$

From equation (i), $\frac{9}{10}g = \frac{g}{\left[1+\left(\frac{h}{R}\right)\right]^2}$

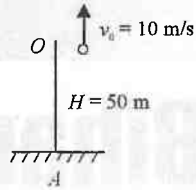
$$1+\frac{h}{R} = \sqrt{\frac{10}{9}} \Rightarrow \frac{h}{R} = \sqrt{\frac{10}{9}} - 1$$

$$\Rightarrow h = \left[\sqrt{\frac{10}{9}} - 1\right]R.$$

On putting numerical values, we get

$$h = \left[\sqrt{\frac{10}{9}} - 1\right]6370 = 344.56 \text{ km.}$$

2. From 3rd equation of motion,



$$v^2 = u^2 + 2a \cdot s$$

$$\Rightarrow v^2 = v_0^2 + 2gH,$$

$$\therefore \quad v = \sqrt{v_0^2 + 2gH}$$

On putting numerical values, we get

$$v = \sqrt{10^2 + 2(9.8)(50)} = 32.86 \text{ m/sec.}$$

3. Given, $l_0 = 30$ cm $= 0.3$ m, $l = 22$ cm $= 0.22$ m

and $F = 0.5$ MN/cm $= \frac{0.5 \times 10^6}{1/100} = 0.5 \times 10^8$

Potential energy of compressed spring is given by

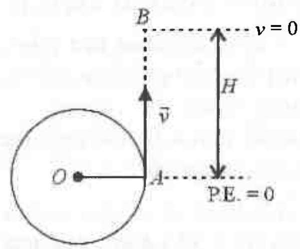
$$U = \frac{1}{2}Fx^2 = \frac{1}{2}F(l_0 - l)^2$$

On putting numerical values, we get

$$U = \frac{1}{2}(0.5 \times 10^8)(0.30 - 0.22)^2 = 1.6 \times 10^5 \text{ J.}$$

4. Given $l = 80$ cm $= 0.8$ m,

$$n = \frac{240}{60} = 4$$



Velocity of stone at point A when the velocity of stone is directed vertically upward is given by

$$v = \omega l = 2\pi n l$$

From conservation of mechanical energy, $E_A = E_B$

$$\frac{1}{2}mv^2 = mgH, \; H = \frac{v^2}{2g} = \frac{4\pi^2 n^2 l^2}{2g} = \frac{2\pi^2 n^2 l^2}{g}$$

On putting numerical values, we get

$$H = \frac{2(10)(4)^2(0.8)^2}{10} = 20.48 \text{ m}$$

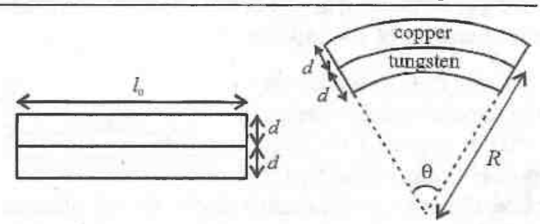
5. Let m be the mass of load that can be lifted by balloon.

$$\rho_{He} Vg + Mg + mg = \rho_{air} Vg$$

$$\therefore \quad m = (\rho_{air} - \rho_{He})V - M$$

$$= (1.2 - 0.18)4000 - 3000 = 1080 \text{ kg.}$$

6.



$$l_{Cu} = l_0(1 + \alpha_{Cu}t)$$

$$l_{tg} = l_0(1 + \alpha_{tg}t)$$

$$\left(\frac{\mu_2-\mu_1}{\mu_3}\right)\frac{1}{R_1}+\left(\frac{\mu_3-\mu_2}{\mu_3}\right)\frac{1}{R_2} \quad \text{... (iii)}$$

... expression for the focal length. If $R_1 = R_2$ we get [Put $R_1 = R_2 = R$ in (iii)]

$$\frac{1}{f}=\left(\frac{\mu_3-\mu_1}{\mu_3}\right)\frac{1}{R},$$ which is independent of μ_2.

17. $\lambda = 5 \times 10^{-7}$ m, $d = 3 \times 10^{-7}$ m, $\mu = 1.17$

$$t = 1.5 \times 10^{-7} \text{ m}, \ \Delta = \frac{(\mu-1)tD}{d}$$

Angular shifting $\delta = \dfrac{\Delta}{D} = \dfrac{(\mu-1)t}{d}$

$$= \frac{(1.17-1)1.5\times10^{-7}}{3\times10^{-7}} = \frac{0.17}{2} = 0.085 \text{ radian.}$$

18. For Lyman series for the first line,

$$\frac{1}{\lambda_1} = R\left(\frac{1}{1}-\frac{1}{4}\right) = \frac{3R}{4} \quad \text{... (i)}$$

For Balmer series (H_α line)

$$\frac{1}{\lambda_2} = R\left(\frac{1}{4}-\frac{1}{9}\right) = \frac{5R}{36} \quad \text{... (ii)}$$

Dividing eqn. (i) by (ii), $\dfrac{\lambda_2}{\lambda_1} = \dfrac{3}{4}\times\dfrac{36}{5} = \dfrac{27}{5}$

$$\Rightarrow \lambda_2 = \frac{27}{5}\lambda_1 = \frac{27}{5}\times 102 \text{ nm} = 550.8 \text{ nm}$$

19. $m_\alpha v_\alpha = m_{\text{residual}} v_r$

$$4v_\alpha = 216\, v_r \ \Rightarrow \ v_r = v_\alpha/54 \quad \text{... (i)}$$

$$\frac{1}{2}m_\alpha v_\alpha^2 + \frac{1}{2}m_r v_r^2 = 5.5 \text{ MeV}$$

$$\Rightarrow \frac{1}{2}(4m)v_\alpha^2 + \frac{1}{2}(216m)\frac{v_\alpha^2}{54} = 5.5\times10^6\times10^{-19} \text{ J}$$

where m is the mass of 1 atomic mass unit.

$$2mv_\alpha^2 + 2mv_\alpha^2 = 5.5\times10^{-13} \text{ J}$$

$$\Rightarrow 4mv_\alpha^2 = 5.5\times10^{-13} \text{ J}$$

$$\Rightarrow v_\alpha = \sqrt{\frac{5.5\times10^{-13}}{4m}} = \sqrt{\frac{5.5\times10^{-13}}{4\times1.67\times10^{-27}}}$$

$$= 9.07\times10^{12} \text{ m/s.}$$

20. $$\lambda = \frac{0.693}{t_{1/2}} = \frac{0.693}{120 \text{ days}} = \frac{0.693}{120\times24\times3600}$$

Activity = λN

$$\therefore N = \frac{\text{Activity}}{\lambda} = \frac{1\times10^{-3}\times3.7\times10^{10}}{\dfrac{0.693}{120\times24\times3600}} = 5.5\times10^{14}$$

$\therefore$ Amount = $(5.5\times10^{14})(208\times1.67\times10^{-27})$ kg
$= 1.9\times10^{-10}$ kg $= 1.9\times10^{-7}$ g.

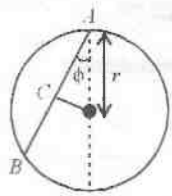
Thought Provoking Problems in Kinematics

By : Prof. R.S. Randhawa*

1. A point P moves uniformly with a velocity u in such a way that the direction of its velocity continually points at another point Q, which in turn moves along a straight line with a uniform velocity u' $(u' < u)$. At the initial moment u and u' are perpendicular to each other and points are separated by a distance d. How soon will the points meet?

2. A ball is thrown from the ground towards a wall of height h with a speed v at an angle θ to the horizontal. Show that the ball must be thrown from a point distant $\dfrac{(v^2\sin^2\theta \pm 2v\cos\theta\sqrt{v^2\sin^2\theta - 2gh})}{2g}$ from the foot of the wall in order that it may just clear it.

3. A smooth frictionless track AB making an angle ϕ with the vertical is made between the highest point A at any other point B of a vertical circle of radius r. Let a particle to start from A with a velocity v.



(a) Calculate the time taken by it to reach B

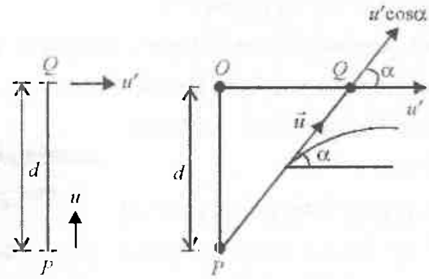
(b) What happens if $v = 0$?

4. A ball rolls off the top of a stairway with a horizontal velocity v ms^{-1}. If the steps are H metre high and b metre wide, show that the ball will hit the edge of the n^{th} step if $n = \dfrac{2Hv^2}{gb^2}$.

5. A ball falls for 6 sec under gravity. It passes through a cardboard, such that its velocity is reduced to one-third. After passing through the cardboard it reaches the ground in 2 sec. What is the height of the cardboard above the ground?

SOLUTIONS

1.



at $t = 0$
fig. (a)

at $t = t$
fig. (b)

The relative velocity of approach of P towards Q is $(u - u'\cos\alpha)$.

The points P and Q will meet after a time T if

$$\int_0^T (u - u'\cos\alpha)\, dt = d \quad \text{... (i)}$$

and $$\int_0^T u\cos\alpha\, dt = u'T \quad \text{... (ii)}$$

Eqn. (i) gives

$$uT - u'\int_0^T \cos\alpha\, dt = d \quad \text{... (iii)}$$

and eqn. (ii) gives

$$\int_0^T \cos\alpha\, dt = \frac{u'T}{u} \quad \text{... (iv)}$$

Put eq. (iv) in eq. (iii), we get

$$uT - u'\cdot\frac{u'T}{u} = d$$

$\therefore$ $(u^2 - u'^2)T = ud$

$\therefore$ $T = \dfrac{ud}{(u^2 - u'^2)}$.

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2. Time taken to cover a horizontal distance R is

$$t = \frac{R}{\cos\theta}$$

$$\therefore \quad y = (v\sin\theta)\left(\frac{R}{v\cos\theta}\right) - \frac{1}{2}g\left(\frac{R}{v\cos\theta}\right)^2$$

The ball will be just able to clear the wall if

$$h = R\tan\theta - \frac{gR^2}{2v^2\cos^2\theta}$$

Solving it we get

$$gR^2 - (v^2\sin 2\theta)R + (2hv^2\cos^2\theta) = 0$$

On solving the quadratic equation, we get

$$\therefore \quad R = \frac{1}{2g}\left(v^2\sin^2\theta \pm 2v\cos\theta\sqrt{v^2\sin^2\theta - 2gh}\right).$$

3. **(a)** From figure, $AC = r\cos\phi$. $\therefore$ $AB = 2r\cos\phi$

Acceleration of the particle down the track $= g\cos\phi$

If t is the time taken by the particle to go down the track,

$$2r\cos\phi = vt + \frac{1}{2}(g\cos\phi)t^2$$

$\therefore$ $g\cos\phi t^2 + 2vt - 4r\cos\phi = 0$

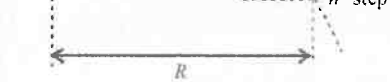
On solving the quadratic equation, we get

$$t = \frac{-v + \sqrt{v^2 + 4rg\cos^2\phi}}{g\cos\phi}.$$

(b) If $v = 0$, $t = t_0 = \dfrac{\sqrt{4rg\cos^2\phi}}{g\cos\phi} = 2\sqrt{\dfrac{r}{g}}$

This is independent of ϕ.

4.



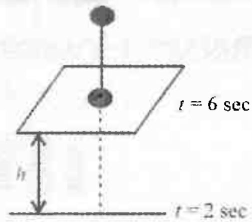
$$nb = vt \quad \text{and} \quad nH = 0 + \frac{1}{2}gt^2$$

Eliminating t between these two equations, we get

$$nH = \frac{1}{2}g\left(\frac{nb}{v}\right)^2 \quad \text{or,} \quad nH = \frac{1}{2}g\frac{n^2b^2}{v^2}$$

or, $n = \dfrac{2Hv^2}{gb^2}$.

5.



$v = 0 + (9.8)(6) = 58.8$ m/s

Velocity after passing through the cardboard is

$$v_1 = \frac{1}{3} \times v = 19.6 \text{ m/s.}$$

Since $v = v_1 t + \frac{1}{2}at^2$

$$= (19.6)(2) + \frac{1}{2}(9.8)(2)^2 = 58.8 \text{ m.}$$

Interest in PHYSICS gave an edge over others

HARSH PAREEK is the new kid on the block. Mumbai s top scorer in the joint entrance exam (JEE), he does not quite behave like he s conquered the world. I worked hard , is all that the 17 year old, who is also all-India rank 8, can bring himself to say. The shy teenager looked awkward as his parents, friends and teachers gathered round to celebrate his achievement.

The Mumbai lad has much to be proud about, apart from his scores in JEE. Recently, he was selected to participate in the International Physics Olympiad. A student of Sathaye College and the son of a doctor, ***the Andheri lad has been interested in Physics since he was a boy It probably gave him an edge over others in the JEE, he thinks***. Keen to pursue computer engineering from IIT- Bombay, Harsh said he enjoys nothing more than working all day on the computer. Speaking about his preparations for the JEE, Harsh said he d undergone extensive training at a local coaching institute.

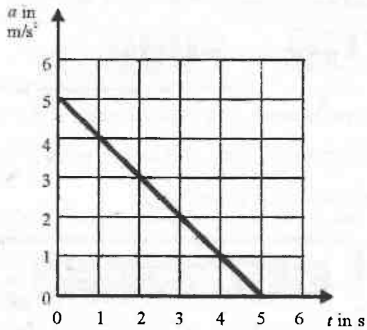
Along with Harsh, over 2,000 students in the western zone comprising Maharashtra, Rajasthan, Goa, Gujrat, parts of Madhya Pradesh and Karnataka made it through the JEE this year. IIT-Bombay zone clearly had an edge over its counterparts, mainly due to coaching facilities in centres such as Kota. Strangely, the number of applicants from this zone had dropped but the number of successful candidates has gone up dramatically.

Train *Your* Brain

This exercise will give your brain the workout it needs!

American Physics Olympiad Problems

1. Starting from rest at time $t = 0$, a car moves in a straight line with an acceleration given by the accompanying graph. What is the speed of the car at $t = 3$ s?



(a) 1.0 m/s
(b) 2.0 m/s (c) 6.0 m/s (d) 10.5 m/s (e) 12.5 m/s

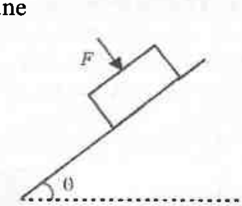
2. A flare is dropped from a plane flying over level ground at a velocity of 70 m/s in the horizontal direction. At the instant the flare is released, the plane begins to accelerate horizontally at 0.75 m/s². The flare takes 4.0 s to reach the ground. Assume air resistance is negligible. Relative to a spot directly under the flare at release, the flare lands

(a) directly on the spot.
(b) 6.0 m in front of the spot.
(c) 274 m in front of the spot.
(d) 280 m in front of the spot.
(e) 286 m in front of the spot.

3. As seen by the pilot of the plane (in question 2) and measured relative to a spot directly under the plane when the flare lands, the flare lands

(a) 286 m behind the plane.
(b) 6.0 m behind the plane.
(c) directly under the plane.
(d) 12 m in front of the plane.
(e) 274 m in front of the plane

4. A force F is used to hold a block of mass m on an incline as shown in the diagram. The plane makes an angle of θ with the horizontal and F is perpendicular to the plane. The coefficient of friction between the plane and the block is μ. What is the minimum force, F, necessary to keep the block at rest?



(a) μmg (b) $mg\cos\theta$
(c) $mg\sin\theta$ (d) $(mg/\mu)\sin\theta$
(e) $(mg/\mu)(\sin\theta - \mu\cos\theta)$

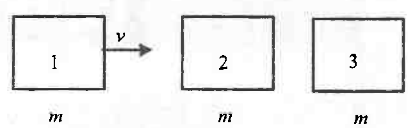
5. You hold a rubber ball in your hand. The Newton's third law companion force to the force of gravity on the ball is the force exerted by the

(a) ball on the earth (b) ball on the hand
(c) hand on the ball (d) earth on the ball
(e) earth on your hand

6. A ball of mass m is fastened to a string. The ball swings in a vertical circle of radius R with the other end of the string held fixed. Neglecting air resistance, the difference between the string's tension at the bottom of the circle and at the top of the circle is

(a) mg (b) $2mg$ (c) $4mg$ (d) $6mg$
(e) $8mg$

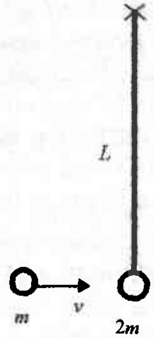
7. Three air track cars, shown in the accompanying figure, all have the same mass m. Cars 2 and 3 are initially at rest. Car 1 is moving to the right with speed v. Car 1 collides with car 2 and sticks to it. The 1-2 combination collides elastically with car 3. Which of the following is most nearly the final speed of car 3?



(a) $0.17v$ (b) $0.50v$ (c) $0.67v$ (d) $0.80v$
(e) $1.0v$

8. A point object of mass $2m$ is attached to one end of a rigid rod of negligible mass and length L. The rod is initially at rest but free to rotate about a fixed axis perpendicular to the rod and passing through its other end (see figure). A second point object with mass m

and initial speed v collides and sticks to the $2m$ object. What is the tangential speed v_t of the object immediately after the collision?



(a) $v/3$
(b) $v/2$
(c) $v/\sqrt{3}$
(d) $v/\sqrt{2}$
(e) $2v/\sqrt{3}$

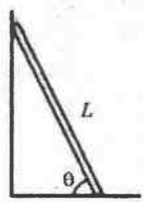
9. Two artificial satellites I and II have circular orbits of radii R and $2R$, respectively, about the same planet. The orbital velocity of satellite I is v. What is the orbital velocity of satellite II?

(a) $v/2$ (b) $v/\sqrt{2}$ (c) v (d) $v\sqrt{2}$
(e) $2v$.

10. The gravitational acceleration on the surface of the moon is 1.6 m/s^2. The radius of the moon is 1.7×10^6 m. The period of a satellite placed in a low circular orbit about the moon is most nearly

(a) 1.0×10^3 s (b) 6.5×10^3 s
(c) 1.1×10^6 s (d) 5.0×10^6 s
(e) 7.1×10^{12} s

11. A uniform ladder of length L rests against a smooth frictionless wall. The floor is rough and the coefficient of static friction between the floor and ladder is μ. When the ladder is positioned at angle θ, as shown in the diagram, it is just about to slip. What is θ?



(a) $\theta = \mu/L$ (b) $\tan\theta = 2\mu$
(c) $\tan\theta = 1/2\mu$ (d) $\sin\theta = 1/\mu$
(e) $\cos\theta = \mu$.

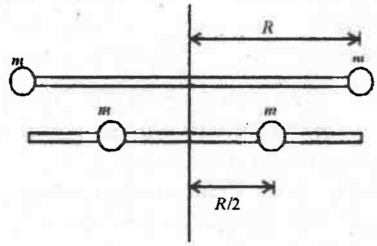
12. Three objects, all of mass M, are released simultaneously from the top of an inclined plane of height H. The objects are described as follows:

I. a cube of side R.
II. a solid cylinder of radius R
III. a hollow cylinder of radius R

Assume the cylinders roll down the plane without slipping and the cube slides down the plane without friction. Which object(s) reach(es) the bottom of the plane first?

(a) I (b) II (c) III (d) I & II
(e) II & III

13. A massless rod of length $2R$ can rotate about a vertical axis through its center as shown in the diagram. The system rotates at an angular velocity ω when the two masses m are a distance R from the axis. The masses are simultaneously pulled to a distance of $R/2$ from the axis by a force directed along the rod. What is the new angular velocity of the system?



(a) $\omega/4$ (b) $\omega/2$ (c) ω (d) 2ω
(e) 4ω

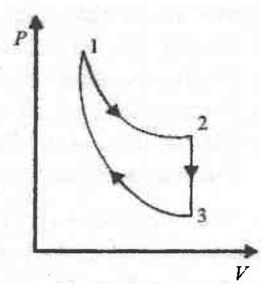
14. A meter stick moves with a velocity of $0.60c$ relative to an observer. The observer measures the length of the meter stick to be L. Which of the following statements is always true?

(a) $L = 0.60$ m (b) $L = 0.80$ m
(c) $L = 0.20$ m (d) $L = 1.00$ m
(e) $L = 0.40$ m

15. A glowing ember (hot piece of charcoal) radiates power P in watts at an absolute temperature T. When the temperature of the ember has decreased to $T/2$, the power it radiates is most nearly

(a) P (b) $P/2$ (c) $P/4$ (d) $P/8$
(e) $P/16$

16. Three processes compose a thermo-dynamic cycle as shown in the PV diagram of an ideal gas. Process $1 \rightarrow 2$ takes place at constant temperature (300 K). During this process 60 J of heat enters the system. Process $2 \rightarrow 3$ takes place at constant volume. During this process 40 J of heat leaves the system. Process $3 \rightarrow 1$ is adiabatic. T_3 is 275 K. What is the change in internal energy of the system during process $3 \rightarrow 1$?



(a) -40 J (b) -20 J (c) 0 (d) $+20$ J
(e) $+40$ J.

17. What is the change in entropy of the system described in Question 16 during the process 3→1?

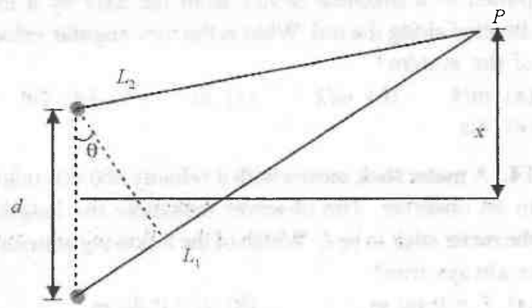
(a) +5.0 K/J (b) +0.20 J/K
(c) 0 (d) −1.6 J/K
(e) −6.9 K/J

18. A wave is described by the equation:

$y(x,t) = 0.030 \sin(5\pi x + 4\pi t)$ where x and y are in metre and t is in second. The $+x$ direction is to the right. What is the velocity of the wave?

(a) 0.80 m/s to the left (b) 1.25 m/s to the left
(c) 0.12π m/s to the right
(d) 0.80 m/s to the right
(e) 1.25 m/s to the right

19.



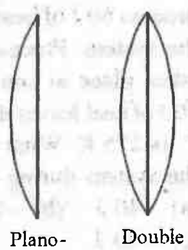
Two sources, in phase and a distance d apart, each emit a wave of wavelength λ. See figure. Which of the choices for the path difference $\Delta L = L_1 - L_2$ will always produce destructive interference at point P?

(a) $d \sin\theta$ (b) x/L_1 (c) $(x/L_2)d$ (d) $\lambda/2$
(e) 2λ

20. You are given two lenses, a converging lens with focal length + 10 cm and a diverging lens with focal length – 20 cm. Which of the following would produce a virtual image that is larger than the object?

(a) Placing the object 5 cm from the converging lens.
(b) Placing the object 15 cm from the converging lens.
(c) Placing the object 25 cm from the converging lens.
(d) Placing the object 15 cm from the diverging lens.
(e) Placing the object 25 cm from the diverging lens.

21. You are given two identical plano-convex lenses, one of which is shown to the right. When you place an object 20 cm to the left of a single plano-convex lens, the image appears 40 cm to the right of the lens. You then arrange the two plano-convex lenses back to back to form a double convex lens.

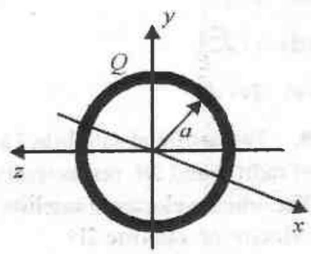


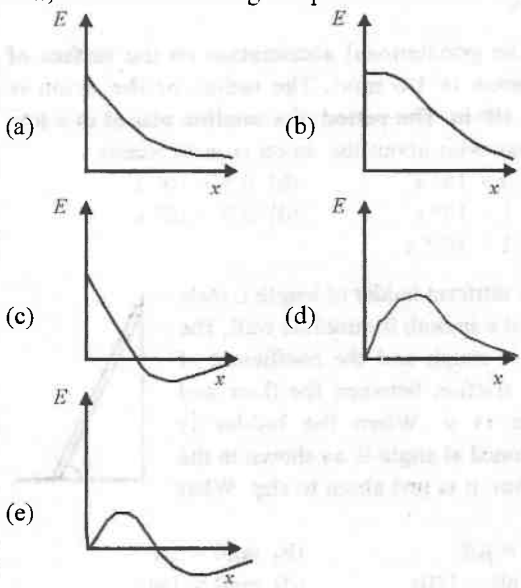
Plano-convex Double Convex

If the object is 20 cm to the left of this new lens, what is the approximate location of the image?

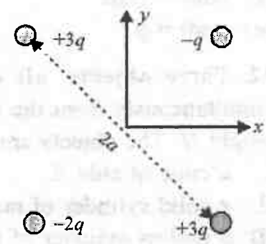
(a) 6.7 cm to the right of the lens.
(b) 10 cm to the right of the lens.
(c) 20 cm to the right of the lens.
(d) 80 cm to the right of the lens.
(e) 80 cm to the left of the lens.

22. Positive charge Q is uniformly distributed over a ring of radius a that lies in the y-z plane as shown in the diagram. The ring is centered at the origin. Which of the following graphs best represents the value of the electric field E as a function of x, the distance along the positive x axis?



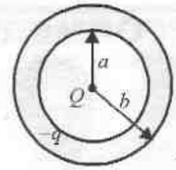


23. Four point charges are placed at the corners of a square with diagonal $2a$ as shown in the diagram. What is the total electric field at the center of the square?



(a) kq/a^2 at an angle 45° above the $+x$ axis.
(b) kq/a^2 at an angle 45° below the $-x$ axis.
(c) $3kq/a^2$ at an angle 45° above the $-x$ axis.
(d) $3kq/a^2$ at an angle 45° below the $+x$ axis.
(e) $9kq/a^2$ at an angle 45° above the $+x$ axis.

Both questions 24 and 25 refer to the system shown in the diagram. A spherical shell with an inner surface of radius a and an outer surface of radius b is made of conducting material. A point charge $+Q$ is placed at the centre of the spherical shell and a total charge $-q$ is placed on the shell.

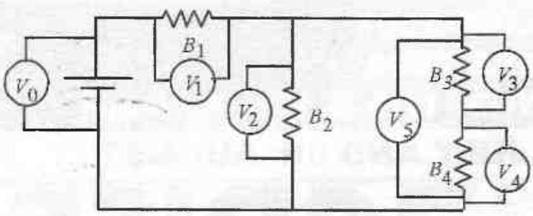


24. How is the charge $-q$ distributed after it has reached equilibrium?
(a) zero charge on the inner surface, $-q$ on the outer surface.
(b) $-Q$ on the inner surface, $-q$ on the outer surface.
(c) $-Q$ on the inner surface, $-q+Q$ on the outer surface.
(d) $+Q$ on the inner surface, $-q-Q$ on the outer surface.
(e) The charge $-q$ is spread uniformly between the inner and outer surface.

25. Assume that the electrostatic potential is zero at an infinite distance from the spherical shell. What is the electrostatic potential at a distance R from the centre of the shell, where $b \geq R \geq a$?

(a) 0 (b) $k\frac{Q}{a}$ (c) $k\frac{Q}{R}$ (d) $k\frac{Q-q}{R}$
(e) $k\frac{Q-q}{b}$

Use the circuit below to answer questions 26 and 27. B_1, B_2, B_3, and B_4 are identical light bulbs. There are six voltmeters connected to the circuit as shown. All voltmeters are connected so that they display positive voltages. Assume that the voltmeters do not effect the circuit.



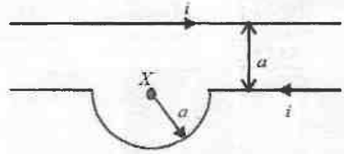
26. If B_2 were to burn out, opening the circuit, which voltmeter(s) would read zero volt?
(a) none would read zero.
(b) only V_2 (c) only V_3 and V_4
(d) only V_3, V_4, and V_5 (e) they would all read zero

27. If B_2 were to burn out, opening the circuit, what would happen to the reading of V_1? Let V be its original reading when all bulbs are functioning and let V' be its reading when B_2 is burnt out.
(a) $V' > 2V$ (b) $2V > V' > V$
(c) $V' = V$ (d) $V > V' > V/2$
(e) $V/2 > V'$

28. A particle with positive charge q and mass m travels along a path perpendicular to a magnetic field. The particle moves in a circle of radius R with frequency f. What is the magnitude of the magnetic field?

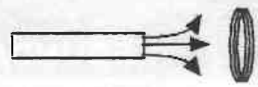
(a) $\frac{mf}{q}$ (b) $\frac{2\pi mf}{q}$ (c) $\frac{m}{2\pi fq}$ (d) $\frac{mf}{qR}$
(e) $\frac{mqf}{2\pi R}$

29. Two wires, each carrying a current i, are shown in the diagram to the right. Both wires extend in a straight line for a very long distance on both the right and the left. One wire contains a semi-circular loop of radius a centered on point X. What is the correct expression for the magnetic field at point X? HINT: The magnitude of the magnetic field at the center of a circular current loop of radius R is $\mu_0 i/(2R)$.



(a) $\frac{\mu_0 i}{4a}+\frac{\mu_0 i}{2\pi a}$ out of the page
(b) $\frac{\mu_0 i}{2a}-\frac{\mu_0 i}{2\pi a}+\frac{\mu_0 i}{2\pi a}$ out of the page
(c) $\frac{\mu_0 i}{4a}+\frac{\mu_0 i}{2\pi a}$ into the page
(d) $\frac{\mu_0 i}{4a}+\frac{\mu_0 i}{2\pi a}+\frac{\mu_0 i}{2\pi a}$ into the page
(e) $\frac{\mu_0 i}{2a}-\frac{\mu_0 i}{2\pi a}$ into the page

30. You are given a bar magnet and a looped coil of wire. Which of the following would induce an emf in the coil?



I. Moving the magnet toward the coil.
II. Moving the coil away from the magnet.
III. Turning the coil about a vertical axis.
(a) I only (b) II only (c) I & II (d) I & III
(e) I, II, III

ANSWERS

1.	(d)	2.	(d)	3.	(b)	4.	(e)	5.	(a)	6.	(d)
7.	(c)	8.	(a)	9.	(b)	10.	(b)	11.	(c)	12.	(a)
13.	(e)	14.	(b)	15.	(e)	16.	(e)	17.	(c)	18.	(a)
19.	(d)	20.	(a)	21.	(b)	22.	(d)	23.	(b)	24.	(c)
25.	(e)	26.	(a)	27.	(d)	28.	(b)	29.	(c)	30.	(e)

SOLVED PAPER 2007

Kerala PMT

1. If a current of 500 mA produces a deflection of 30° in a tangent galvanometer, then the current that produces a deflection of 60° is
(a) 1.5 A (b) 1 A
(c) 500 mA (d) 866 mA
(e) 2 A.

2. A wire of length 50 cm moves with a velocity of 300 m/min, perpendicular to a magnetic field. If the emf induced in the wire is 2 V, the magnitude of the field in tesla is
(a) 2 (b) 5 (c) 0.4
(d) 2.5 (e) 0.8

3. Whenever a magnet is moved either towards or away from a conducting coil, an emf is induced, the magnitude of which is independent of
(a) the strength of the magnetic field
(b) the speed with which the magnet is moved
(c) the number of turns in the coil
(d) the resistance of the coil
(e) the area of cross section of the coil.

4. The instantaneous voltage through a device of impedance 20 Ω is $e = 80\sin 100\pi t$. The effective value of the current is
(a) 3 A (b) 2.828 A (c) 1.732 A
(d) 4 A (e) $\sqrt{2}$ A.

5. An electromagnetic radiation has an energy of 13.2 keV. Then the radiation belongs to the region of
(a) visible light (b) ultraviolet
(c) infrared (d) X-ray
(e) microwave.

6. Two convex lenses of focal lengths 0.3 m and 0.05 m are used to make a telescope. The distance kept between the two in order to obtain an image at infinity is
(a) 0.35 m (b) 0.25 m (c) 0.175 m
(d) 0.15 m (e) 0.20 m.

7. The refractive indices of glass and water with respect to air are 3/2 and 4/3 respectively. Then the refractive index of glass with respect to water is
(a) 8/9 (b) 9/8 (c) 7/6
(d) 2 (e) 0.5

8. In a two-slit experiment, with monochromatic light, fringes are obtained on a screen placed at some distance from the slits. If the screen is moved by 5×10^{-2} m towards the slits, the change in fringe width is 10^{-3} m. Then the wavelength of light used is (given that distance between the slits is 0.03 mm)
(a) 4000 Å (b) 4500 Å (c) 5000 Å
(d) 5500 Å (e) 6000 Å.

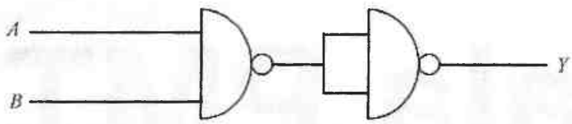
9. The photosensitive surface is receiving light of wavelength 5000 Å at the rate of 10^{-8} J/s. The number of photons received per second is
(a) 2.5×10^{10} (b) 2.5×10^{11}
(c) 2.5×10^{12} (d) 2.5×10^{9}
(e) 2.5×10^{13}.

10. The nucleus ${}_6C^{12}$ absorbs an energetic neutron and emits a beta particle (β). The resulting nucleus is
(a) ${}_7N^{14}$ (b) ${}_7N^{13}$ (c) ${}_5B^{13}$
(d) ${}_6C^{13}$ (e) ${}_5B^{12}$.

11. Select the true statement from the following. Nuclear force is
(a) strong, short range and charge independent force
(b) charge independent, attractive and long range force
(c) strong, charge dependent and short range attractive force
(d) long range, charge dependent and attractive force
(e) charge independent, short range and strong repulsive force.

12. In *CE* mode, the input characteristics of a transistor is the variation of
(a) I_B against V_{BE} at constant V_{CE}
(b) I_C against V_{CE} at constant V_{BE}
(c) I_B against I_C (d) I_E against I_C
(e) I_C against V_{CE} at constant I_B.

13. The arrangement shown in the figure performs the logic function of



(a) AND gate (b) OR gate
(c) NAND gate (d) NOR gate
(e) NOT gate.

14. The electrical conductivity of an intrinsic semiconductor at 0 K is
(a) less than that of an insulator
(b) is equal to zero (c) is equal to infinity
(d) more than that of an insulator
(e) is equal to that of a metal.

15. The principle used for the transmission of light signals through the optical fibre is
(a) reflection (b) refraction
(c) interference (d) diffraction
(e) total internal reflection.

16. The sky wave propagation is suitable for radio-waves of frequency
(a) upto 2 MHz (b) from 2 MHz to 20 MHz
(c) from 2 MHz to 30 MHz
(d) from 2 MHz to 50 MHz
(e) from 2 MHz to 80 MHz.

17. Modulation is the process of superposing
(a) low frequency audio signal on high frequency waves
(b) low frequency radio signal on low frequency audio waves
(c) high frequency radio signal on low frequency audio signal
(d) high frequency audio signal on low frequency radio waves
(e) low frequency radio signal on high frequency audio waves.

18. If voltage $V = (100 \pm 5)$ V and current $I = (10 \pm 0.2)$ A, the percentage error in resistance R is
(a) 5.2% (b) 25% (c) 7%
(d) 10% (e) 2.5%.

19. A body starting from rest moves with uniform acceleration. The distance covered by the body in time t is proportional to
(a) $\sqrt{t}$ (b) $t^{3/2}$ (c) $t^{2/3}$
(d) t^3 (e) t^2.

20. A pendulum of length 1 m is released from $\theta = 60°$. The rate of change of speed of the bob at $\theta = 30°$ is ($g = 10\ \mathrm{ms^{-2}}$)
(a) $10\ \mathrm{ms^{-2}}$ (b) $7.5\ \mathrm{ms^{-2}}$
(c) $5\ \mathrm{ms^{-2}}$ (d) $5\sqrt{3}\ \mathrm{ms^{-2}}$
(e) $2.5\ \mathrm{ms^{-2}}$.

21. A body constrained to move in the y-direction is subjected to a force $\vec{F} = 2\hat{i} + 15\hat{j} + 6\hat{k}$ newton. The work done by this force in moving the body through a distance of 10 m along y-axis is
(a) 100 J (b) 150 J (c) 120 J
(d) 200 J (e) 50 J.

22. A particle is projected with a speed v at 45° with the horizontal. The magnitude of angular momentum of the projectile about the point of projection when the particle is at its maximum height h is
(a) zero (b) $\frac{mvh^2}{\sqrt{2}}$ (c) $\frac{mv^2h}{2}$
(d) $\frac{mvh^3}{\sqrt{2}}$ (e) $\frac{mvh}{\sqrt{2}}$.

23. A gun fires bullets each of mass 1 g with velocity of $10\ \mathrm{ms^{-1}}$ by exerting a constant force of 5 g weight. Then the number of bullets fired per second is (Take $g = 10\ \mathrm{ms^{-2}}$)
(a) 50 (b) 5 (c) 10
(d) 25 (e) 15.

24. Two equal forces are acting at a point with an angle of 60° between them. If the resultant force is equal to $40\sqrt{3}$ N, the magnitude of each force is
(a) 40 N (b) 20 N (c) 80 N
(d) 30 N (e) 10 N.

25. A man pushes against a wall but fails to move it. He does
(a) negative work
(b) positive but not maximum work
(c) maximum positive work
(d) no work at all
(e) maximum negative work.

26. When a bullet is fired at a target, its velocity decreases by half after penetrating 30 cm into it. The additional thickness it will penetrate before coming to rest is
(a) 30 cm (b) 40 cm (c) 10 cm
(d) 50 cm (e) 20 cm.

27. The moment of inertia of a flywheel having kinetic

energy 360 J and angular speed of 20 rad/s is

(a) 18 kg m^2 (b) 1.8 kg m^2
(c) 2.5 kg m^2 (d) 9 kg m^2
(e) 0.9 kg m^2.

28. Four point masses P, Q, R and S with respective masses 1 kg, 1 kg, 2 kg and 2 kg form the corners of a square of side a. The centre of mass of the system will be farthest from

(a) P only (b) R and S
(c) R only (d) P and Q
(e) P and R.

29. The satellite of mass m revolving in a circular orbit of radius r around the earth has kinetic energy E. Then its angular momentum will be

(a) $\sqrt{\dfrac{E}{mr^2}}$ (b) $\dfrac{E}{2mr^2}$

(c) $\sqrt{2Emr^2}$ (d) $\sqrt{2Emr}$

(e) $\sqrt{\dfrac{E}{2mr^2}}$.

30. The escape velocity from the earth is 11.2 km/s. The escape velocity from a planet having twice the radius and the same mean density is (in km/s)

(a) 11.2 (b) 5.6 (c) 15
(d) 22.4 (e) 33.6

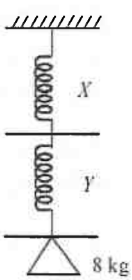
31. The excess of pressure inside the first soap bubble is three times that inside the second bubble. The ratio of volume of the first to that of the second bubble is

(a) 1 : 3 (b) 1 : 9 (c) 1 : 27
(d) 9 : 1 (e) 27 : 1.

32. Bernouilli's principle is based on the law of conservation of

(a) mass (b) momentum
(c) pressure (d) energy
(e) volume.

33. A body of mass 8 kg is suspended through two light springs X and Y connected in series as shown in figure. The readings in X and Y respectively are



(a) 8 kg, zero
(b) zero, 8 kg
(c) 6 kg, 2 kg
(d) 2 kg, 6 kg
(e) 8 kg, 8 kg.

34. A body cools from 62°C to 50°C in 10 minutes and to 42°C in the next 10 minutes. The temperature of the surrounding is

(a) 16°C (b) 26°C (c) 36°C
(d) 21°C (e) 31°C.

35. At what temperature the kinetic energy of a gas molecule is half of the value at 27°C?

(a) 13.5°C (b) 150°C (c) 75 K
(d) 13.5 K (e) –123 K.

36. A black body emits radiations of maximum intensity for the wavelength of 5000 Å when the temperature of the body is 1227°C. If the temperature of the body is increased by 1000°C, the maximum intensity would be observed at

(a) 1000 Å (b) 2000 Å (c) 5000 Å
(d) 4000 Å (e) 3000 Å.

37. A simple pendulum has a time period T in vacuum. Its time period when it is completely immersed in a liquid of density one-eighth of the density of material of the bob is

(a) $\sqrt{\frac{7}{8}}T$ (b) $\sqrt{\frac{5}{8}}T$ (c) $\sqrt{\frac{3}{8}}T$

(d) $\sqrt{\frac{8}{7}}T$ (e) $\sqrt{\frac{8}{5}}T$.

38. A body of mass 20 g connected to spring of constant K executes simple harmonic motion with a frequency of $(5/\pi)$ Hz. The value of spring constant is

(a) 4 Nm^{-1} (b) 3 Nm^{-1} (c) 2 Nm^{-1}
(d) 5 Nm^{-1} (e) 2.5 Nm^{-1}.

39. Two waves are given by $y_1 = \cos(4t - 2x)$ and $y_2 = \sin\left(4t - 2x + \frac{\pi}{4}\right)$. The phase difference between the two waves is

(a) $\pi/4$ (b) $-\pi/4$ (c) $3\pi/4$
(d) $\pi/2$ (e) $3\pi/2$.

40. A wave represented by the equation $y = a\cos(kx - \omega t)$ is superposed with another wave to form a stationary wave such that the point $x = 0$ is a node. The equation for the other wave is

(a) $y = a\cos[kx + \omega t]$ (b) $y = a\sin[kx + \omega t]$
(c) $y = -a\sin[kx + \omega t]$ (d) $y = -a\sin[kx - \omega t]$
(e) $y = -a\cos[kx + \omega t]$.

41. An electric dipole consists of two opposite charges

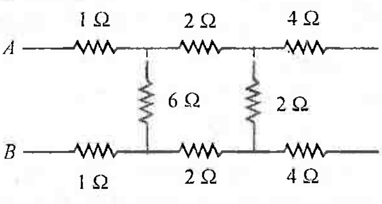
each 0.05 μC separated by 30 mm. The dipole is placed in an uniform external electric field of 10^6 NC^{-1}. The maximum torque exerted by the field on the dipole is
(a) 6×10^{-3} Nm (b) 3×10^{-3} Nm
(c) 15×10^{-3} Nm (d) 1.5×10^{-3} Nm
(e) 9×10^{-3} Nm.

42. Two identical spheres carrying charges –9 μC and 5 μC respectively are kept in contact and then separated from each other. Point out true statement from the following. In each sphere
(a) 1.25×10^{13} electrons are in deficit
(b) 1.25×10^{13} electrons are in excess
(c) 2.15×10^{13} electrons are in excess
(d) 2.15×10^{13} electrons are in deficit
(e) 1.52×10^{13} electrons are in excess.

43. The capacitance of a parallel plate capacitor with air as medium is 3 μF. With the introduction of a dielectric medium between the plates, the capacitance becomes 15 μF. The permitivity of the medium is
(a) 5 (b) 15
(c) 0.44×10^{-10} C^2 N^{-1} m^{-2}
(d) 8.854×10^{-11} C^2 N^{-1} m^{-2}
(e) 5 C^2 N^{-1} m^{-2}.

44. The colour code for a resistor of resistance 3.5 kΩ with 5% tolerance is
(a) orange, green, orange and gold
(b) red, yellow, black and gold
(c) orange, green, orange and silver
(d) orange, green, red and silver
(e) orange, green, red and gold.

45. In the adjoining figure the equivalent resistance between A and B is



(a) 5 Ω (b) 8 Ω (c) 2.5 Ω
(d) 6.8 Ω (e) 7.8 Ω.

46. In a Wheatstone's network, P = 2 Ω, Q = 2 Ω, R = 2 Ω and S = 3 Ω. The resistance with which S is to be shunted in order that the bridge may be balanced is
(a) 1 Ω (b) 2 Ω (c) 4 Ω
(d) 6 Ω (e) 8 Ω.

47. The strength of the magnetic field around a long straight wire, carrying current, is
(a) same everywere around the wire at any distance
(b) inversely proportional to the distance from the wire
(c) inversely proportional to the square of the distance from the wire
(d) directly proportional to the square of the distance from the wire
(e) directly proportional to the distance from the wire.

48. A proton with energy of 2 MeV enters a uniform magnetic field of 2.5 T normally. The magnetic force on the proton is (Take mass of proton to be 1.6×10^{-27} kg)
(a) 3×10^{-12} N (b) 8×10^{-10} N
(c) 8×10^{-12} N (d) 2×10^{-10} N
(e) 3×10^{-10} N.

SOLUTIONS

1. (a) : For a tangent galvanometer, $I = K\tan\theta$ where K is the reduction factor of tangent galvanometer.

$$\therefore \quad \frac{I_1}{I_2} = \frac{\tan\theta_1}{\tan\theta_2} \quad \text{or} \quad \frac{500}{I_2} = \frac{\tan 30^\circ}{\tan 60^\circ}$$

$$\text{or.} \quad I_2 = 500 \times \frac{\tan 60^\circ}{\tan 30^\circ} = 500 \times \frac{\sqrt{3}}{1/\sqrt{3}}$$

$$= 500 \times 3 = 1500 \text{ mA} = 1.5 \text{ mA.}$$

2. (e) : When a wire of length l moves with velocity v, perpendicular to a magnetic field B, the induced emf is produced. The magnitude of induced emf is given by

$$|\varepsilon| = Blv$$

Given : l = 50 cm = 0.5 m, v = 300 m/min = 5 m/sec

$$|\varepsilon| = 2 \text{ V.}$$

$$\text{or,} \quad B = \frac{|\varepsilon|}{lv} = \frac{2}{0.5 \times 5} = 0.8 \text{ tesla.}$$

3. (d) : Induced emf. depends on the total flux × current per second, *i.e.* on the strength of the magnet, speed of moving the magnet, number of turns of the coil and area of cross-section of the coil. Only the current is decided by the emf and the resistance.

$\therefore$ emf is independent of the resistance of the coil.

4. (b) : Given equation, $e = 80\sin 100\pi t$ ... (i)
Standard equation of instantaneous voltage is given by

$$e = e_m \sin\omega t \quad \text{... (ii)}$$

Compare (i) and (ii), we get e_m = 80 V
where e_m is the voltage amplitude.

Current amplitude $I_m = \frac{e_m}{Z}$ where Z = impedance

$$= 80/20 = 4 \text{ A.}$$

Effective current or root mean square current,

$$I_{r.m.s.} = \frac{4}{\sqrt{2}} = \frac{4\sqrt{2}}{2} = 2\sqrt{2} = 2.828 \text{ A}.$$

5. **(d)** : Given: $E = 13.2$ keV

$$\lambda \text{ (in Å)} = \frac{hc}{E(\text{eV})} = \frac{12400}{13.2\times10^{3}} = 0.939 \text{ Å} \approx 1 \text{ Å}.$$

X-rays covers wavelengths ranging from about 10^{-8} m (10 nm) to 10^{-3} m (10^{-4} nm).
An electromagnetic radiation of energy 13.2 keV belongs to X-ray region of electromagnetic spectrum.

6. **(a)** : In a telescope, to obtain an image at infinity or in normal adjustment, the distance between two convex lenses one called objective (greater focal length) and the other called eye piece (shorter focal length) is L.

$$L = f_o + f_e = 0.3 + 0.05 = 0.35 \text{ m}.$$

7. **(b)** : Given: ${}^{a}\mu_g = \frac{3}{2}$, ${}^{a}\mu_w = \frac{4}{3}$

$\therefore \quad {}^{a}\mu_w \times {}^{w}\mu_g = {}^{a}\mu_g$

or, $\quad {}^{w}\mu_g = \frac{{}^{a}\mu_g}{{}^{a}\mu_w} = \frac{3/2}{4/3} = \frac{9}{8}.$

8. **(e)** : Fringe width $\beta = \frac{\lambda D}{d}$

where D is the distance between slit and the screen, d is the distance between two slits, λ is the wavelength of light.

$$\therefore \quad \Delta\beta = \frac{\lambda \Delta D}{d}$$

$$\text{or} \quad \lambda = \frac{\Delta\beta d}{\Delta D} = \frac{10^{-3}\times0.03\times10^{-3}}{5\times10^{-2}} = \frac{10^{-3}\times3\times10^{-5}}{5\times10^{-2}}$$
$$= 6 \times 10^{-7} \text{ m} = 6000 \text{ Å}.$$

9. **(a)** : Given : $\lambda = 5000$ Å
Energy received per second = 10^{-8} J/sec

$\therefore$ Energy of one photon is $E = h\upsilon = \frac{hc}{\lambda}$

$$= \frac{6.63\times10^{-34}\times3\times10^{8}}{5000\times10^{-10}} = 3.99\times10^{-19} \text{ J}.$$

$\therefore$ Number of photons received per second

$$= \frac{\text{Energy received per second}}{\text{Energy of one photon}}$$

$$= \frac{10^{-8}}{3.99\times10^{-19}} = 2.5\times10^{10}.$$

10. **(b)** : ${}_{6}C^{12} + {}_{0}n^{1} \rightarrow {}_{7}N^{13} + {}_{-1}e^{0} + \bar{\nu}$
(neutron) (resulting nucleus) (β-particle) (antineutrino)

11. **(a)** : *Properties of nuclear force*

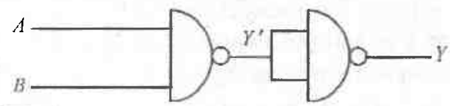
(i) Nuclear force acts between a pair of neutrons, a pair of protons and also between a proton and neutron with equal strength. This shows nuclear force does not depend on charge *i.e.* charge independent.

(ii) Nuclear force is the strongest force in nature. Nuclear force is 100 times that of electrostatic force and 10^{39} times that of gravitational force between nucleons.

(iii) Nuclear force is a short range force. The range of the nuclear force is the order of 2 to 3 fm.

12. **(a)** : The input characteristics of the CE mode transistor (common emitter mode) represents the variation of the input current *i.e.* base current I_B with input voltage *i.e.* base emitter voltage V_{BE} at constant output voltage *i.e.* collector emitter voltage V_{CE}.

13. **(a)** :



$$Y' = \overline{A \cdot B}$$

$$Y = \overline{\overline{A \cdot B}} = A \cdot B$$

The given circuit performs the logic function of AND gate.

14. **(b)** : At 0 K, intrinsic semiconductor behaves like an insulator. Therefore, the electrical conductivity of an intrinsic semiconductor at 0 K is equal that of an insulator.

15. **(e)** : The transmission of light signals through optical fibre is based on the principle of total internal reflection.

16. **(c)** : The sky waves are the radiowaves of frequency between 2 MHz to 30 MHz. These waves can propagate through atmosphere and are reflected back the ionosphere of earth's atmosphere.

17. **(a)** : Modulation is a process of superposing a low frequency audio signals (called modulating signal) on a high frequency radio wave called carrier wave.

18. **(c)** : Given : Voltage $V = (100 \pm 5)$ V
Current $I = (10 \pm 0.2)$ A
According to Ohm's law, $V = IR$ or $R = V/I$
Taking log of both sides,

$$\log R = \log V - \log I$$

Differentiating, we get

$$\frac{\Delta R}{R} = \frac{\Delta V}{V} - \frac{\Delta I}{I}.$$

For maximum error, $\dfrac{\Delta R}{R} = \dfrac{\Delta V}{V} + \dfrac{\Delta I}{I}$.

Multiplying both sides by 100 for taking percentage, we get

$$\frac{\Delta R}{R}\times 100 = \frac{\Delta V}{V}\times 100 + \frac{\Delta I}{I}\times 100$$

Percentage error in resistance R

$$= \frac{\Delta V}{V}\times 100 + \frac{\Delta I}{I}\times 100 = \frac{5}{100}\times 100 + \frac{0.2}{10}\times 100$$

$= 7\%$.

19. (e) : Given : Initial velocity of a body $u = 0$ ... (i)

Let s be the distance covered by a body in time t

$\therefore \quad s = ut + \frac{1}{2}at^2 \quad$ or $\quad s = \frac{1}{2}at^2 \quad$ [using (i)]

or, $s \propto t^2$.

20. (c) : ω^2 for a pendulum is g/l.

When θ is half the amplitude of 60°.

acceleration $= -\omega^2\theta$

$\Rightarrow \quad a = -\dfrac{10}{1}\times\dfrac{\pi}{6} = -5 \text{ ms}^{-2}$.

21. (b) : Force $\vec{F} = 2\hat{i} + 15\hat{j} + 6\hat{k}$ N

Displacement, $\vec{s} = 0\hat{i} + 10\hat{j} + 0\hat{k}$ m

$\therefore$ Workdone $W = \vec{F}\cdot\vec{s}$

$= (2\hat{i} + 15\hat{j} + 6\hat{k})\cdot(0\hat{i} + 10\hat{j} + 0\hat{k}) = 150$ J.

22. (e) : Velocity of a particle at maximum height h is

$v' = v\cos\theta$

where v = initial velocity of particle at which it is projected.

θ = angle of projection

Angular momentum, $L = mv'h = mv\cos\theta\, h$

$= mvh\cos 45° = \dfrac{mvh}{\sqrt{2}}$.

23. (b) : Given, mass $m = 1$ g $= 0.001$ kg

Force $F = 5$ gwt $= 5 \times 10^3$ dyne $= 0.05$ N

(1 N $= 10^5$ dyne)

Velocity $v = 10$ ms^{-1}

$\therefore$ Number of bullets fired per second $= F/mv$

$$= \frac{0.05}{0.001\times 10} = 5.$$

24. (a) : Given : Force F_1 = force $F_2 = F$

or, $F_1 = F_2 = F$

Resultant force $R = 40\sqrt{3}$ N

Angle between two forces F_1 and F_2 is $\theta = 60°$

$\therefore \quad R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$

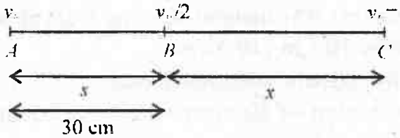
or, $40\sqrt{3} = \sqrt{F^2 + F^2 + 2F^2\cos 60°} = \sqrt{3F^2}$

or, $F = 40$ N.

25. (d) : Work done is defined as $\vec{F}\cdot\vec{s}$.

But the wall does not move even when the force is applied. Therefore no work is done.

26. (c) :



Let bullet is fired with velocity v_B at point A and its velocity becomes half when it travels a distance s and reaches at point B. When it reaches at point C, it comes to rest and travels a distance x.

From A to B, using, $v^2 - u^2 = 2as$

or $\left(\dfrac{v_B}{2}\right)^2 - v_B^2 = 2as \quad$ or $\quad \dfrac{v_B^2}{4} - v_B^2 = 2as$

or $\dfrac{-3v_B^2}{4} = 2as \quad$ or $\quad a = \dfrac{-3v_B^2}{8s}$

$\therefore$ From B to C, using $v^2 - u^2 = 2as$

$0^2 - \left(\dfrac{v_B}{2}\right)^2 = 2ax \quad$ or $\quad \dfrac{-v_B^2}{4} = 2\left(\dfrac{-3v_B^2}{8s}\right)x$

or $\quad x = \dfrac{8s}{4\times 6} = \dfrac{8\times 30}{24} = 10$ cm.

27. (b) : Given: kinetic energy $K = 360$ J

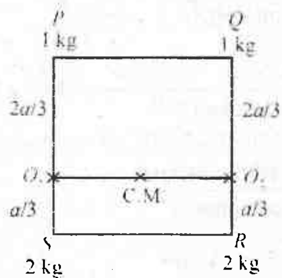
Angular speed $\omega = 20$ rad/s

$\therefore \quad K = \frac{1}{2}I\omega^2$

where I = moment of inertia

or, $I = \dfrac{2K}{\omega^2} = \dfrac{2\times 360}{20\times 20} = 1.8 \text{ kg m}^{-2}$.

28. (d) :



Centre of mass of P and S will be at O_1, Q and R will be at O_2.

$\therefore$ The centre of mass of all at centre of mass which is at the midpoint of O_1 and O_2 farthest from P and Q.

29. **(c) :** Kinetic energy of a satellite $E=\frac{1}{2}mv^2$

where m = mass of a satellite and v = orbital velocity of a satellite

$$E=\frac{1}{2}mv^2 \quad \text{or} \quad mE=\frac{1}{2}m^2v^2 \quad \text{or} \quad mv=\sqrt{2mE}$$

Angular momentum $L = mvr = \sqrt{2mE}\,r = \sqrt{2mEr^2}$.

30. **(d) :** Let M_e, R_e, ρ_e be the mass, radius and density of earth and M_p, R_p, ρ_p be the corresponding values for the planet.

Then escape velocity from the earth's surface is

$$v_e=\sqrt{\frac{2GM_e}{R_e}} = \sqrt{\frac{2G}{R_e}\times\rho_e\times\frac{4}{3}\pi R_e^3}$$

$$=\sqrt{\frac{8\pi G\rho_e R_e^2}{3}}$$

Escape velocity from the planet's surface is

$$v_p=\sqrt{\frac{8\pi G\rho_p R_p^2}{3}} = \sqrt{\frac{8\pi G\rho_e(2R_e)^2}{3}}$$

(Given : $\rho_p = \rho_e$, $R_p = 2R_e$)

$$=2\sqrt{\frac{8\pi G\rho_e R_e^2}{3}} = 2\times 11.2 = 22.4 \text{ km/s}.$$

31. **(c) :** Excess pressure inside a soap bubble $P=\frac{4T}{R}$

where T is the surface tension of the soap solution, R is the radius of a soap bubble.

$$\therefore \frac{P_1}{P_2}=\frac{R_2}{R_1} \quad \text{or} \quad \frac{3P_2}{P_2}=\frac{R_2}{R_1} \quad \text{or} \quad \frac{R_1}{R_2}=\frac{1}{3}$$

$$\therefore \frac{V_1}{V_2}=\frac{\frac{4}{3}\pi R_1^3}{\frac{4}{3}\pi R_2^3}=\left(\frac{R_1}{R_2}\right)^3=\left(\frac{1}{3}\right)^3=\frac{1}{27}.$$

32. **(d) :** Bernouilli's principle is based on the conservation of energy.

33. **(e) :** As X and Y have negligible mass, both the spring balances read the same force $8 \times g$ or 8 kg. When massless springs are connected in series, the force is the same.

34. **(b) :** Let the temperature of the surrounding be θ_0. According to Newton's law of cooling,

$$\frac{62-50}{10} = K\left(\frac{62+50}{2}-\theta_0\right)$$

$$\text{or} \quad \frac{12}{10} = K\left[\frac{112}{2}-\theta_0\right] \quad \text{... (i)}$$

$$\text{and} \quad \frac{50-42}{10} = K\left[\frac{50+42}{2}-\theta_0\right]$$

$$\text{or} \quad \frac{8}{10} = K\left[\frac{92}{2}-\theta_0\right] \quad \text{... (ii)}$$

Divide (i) by (ii), we get

$$\frac{12}{10}\times\frac{10}{8} = \frac{112-2\theta_0}{92-2\theta_0} \quad \text{or} \quad \frac{3}{2} = \frac{112-2\theta_0}{92-2\theta_0}$$

$$\text{or} \quad 276-6\theta_0 = 224-4\theta_0$$

$$\text{or} \quad 276-224 = 2\theta_0 \quad \text{or} \quad \theta_0 = \frac{52}{2} = 26°\text{C}.$$

35. Kinetic energy of a gas molecule $K=\frac{3}{2}kT$

where k is the Boltzmann's constant and T is the temperature in kelvin.

$$\therefore \frac{K}{K'}=\frac{T}{T'} \quad \text{or} \quad \frac{K}{K/2}=\frac{300}{T'}$$

$$\text{or} \quad 2=\frac{300}{T'} \quad \text{or} \quad T'=150\text{ K}=-123°\text{C}.$$

This option is not provided in the question paper.

36. **(e) :** According to Wein's law $\lambda_{max}T=\text{constant}$ where T is the temperature in kelvin.

$$\therefore \frac{(\lambda_{max})_1}{(\lambda_{max})_2}=\frac{T_2}{T_1}=\frac{2227+273}{1227+273}$$

$$\frac{(\lambda_{max})_1}{(\lambda_{max})_2}=\frac{2500}{1500}=\frac{5}{3}$$

$$\text{or,} \quad (\lambda_{max})_2=\frac{3}{5}\times(\lambda_{max})_1=\frac{3}{5}\times 5000=3000 \text{ Å}.$$

37. **(d) :** Let $T=2\pi\sqrt{\frac{l}{g}}$

Let V be the volume of the mass.

$V\times\rho\times g$ is acting downwards.

$V\times\frac{\rho}{8}\times g$ is acting upwards.

Inside the liquid, the effective force downwards

$$=V\rho g\times\frac{7}{8} \quad i.e. \text{ effective } g \text{ is } \frac{7}{8}g.$$

$$\therefore \quad T'=2\pi\sqrt{\frac{l}{(7/8)g}} \Rightarrow T'=2\pi\sqrt{\frac{8l}{7g}}=\sqrt{\frac{8}{7}}T.$$

38. (c) : Given : Frequency of oscillation $\upsilon = \frac{5}{\pi}$ Hz

Mass of a body m = 20 g = 0.02 kg

Frequency of oscillation $\upsilon = \frac{1}{2\pi}\sqrt{\frac{K}{m}}$

where K is the spring constant

or $\upsilon^2 = \frac{1}{4\pi^2}\frac{K}{m}$

$\therefore \quad K = 4\pi^2\upsilon^2 m = 4\pi^2\left(\frac{5}{\pi}\right)^2 \times 0.02 = 2\ \text{Nm}^{-1}$.

39. (b) : $y_1 = \cos(4t - 2x) = \sin\left(4t - 2x + \frac{\pi}{2}\right)$

$y_2 = \sin\left(4t - 2x + \frac{\pi}{4}\right)$

Phase difference between two waves is

$$\Delta\phi = \left(4t - 2x + \frac{\pi}{4}\right) - \left(4t - 2x + \frac{\pi}{2}\right) = \frac{\pi}{4} - \frac{\pi}{2} = -\frac{\pi}{4}.$$

40. (e) : Stationary wave is formed by superposition of two identical waves travelling in opposite directions.

Given wave is $y = a\cos(kx - \omega t)$

The other wave cannot be $y = -a\cos(kx - \omega t)$ as their directions are not opposite. The other possible cosine function can be $y = -a\cos(kx + \omega t)$.

Their directions are opposite to each other.

$\therefore \quad y_s = a\cos(kx - \omega t) - a\cos(kx + \omega t)$
$= 2a\sin kx \sin\omega t$

At $x = 0$, $y_s = 0$

Hence a node is formed at $x = 0$.

$\therefore$ The equation of other wave $= -a\cos(kx + \omega t)$.

41. (d) : Torque $\vec{\tau} = \vec{p} \times \vec{E}$

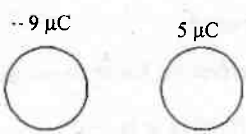
where $\vec{p}$ = electric dipole moment, $\vec{E}$ = electric field

or $\tau = pE\sin\theta$

For maximum torque, $\theta = 90°$

or $\tau = pE = 0.05 \times 10^{-6} \times 30 \times 10^{-3} \times 10^{6}$
$= 1.5 \times 10^{-3}$ Nm.

42. (b) :



After initial contact and separation, each sphere will be having -2 μC each

$\therefore \quad n = \frac{-2\times10^{-6}}{-1.6\times10^{-19}} = 1.25\times10^{13}$.

i.e. 1.25×10^{13} electrons in excess.

43. (c) : Capacitance of a parallel plate capacitor with air is $C = \frac{\varepsilon_0 A}{d}$

Capacitance of a same parallel plate capacitor with the introduction of a dielectric medium is $C' = \frac{K\varepsilon_0 A}{d}$

where K is the dielectric constant of a medium

or $\frac{C'}{C} = K$ or $K = \frac{15}{3} = 5$ or $K = \frac{\varepsilon_r}{\varepsilon_0}$

or $\varepsilon_r = K\varepsilon_0 = 5 \times 8.854 \times 10^{-12}$
$= 0.4427 \times 10^{-10}\ \text{C}^2\ \text{N}^{-1}\ \text{m}^{-2}$.

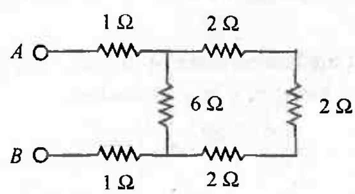
44. (e) : The first two bands from the end indicate the first two significant figures of the resistance in ohm. The third band indicates the decimal multiplier and the last band stands for the tolerance in percent about the indicated value.

Resistor colour codes

Colour	Number	Multiplier	Tolerence (%)
Black	0	1	
Brown	1	10^1	
Red	2	10^2	
Orange	3	10^3	
Yellow	4	10^4	
Green	5	10^5	
Blue	6	10^6	
Violet	7	10^7	
Gray	8	10^8	
White	9	10^9	
Gold		10^{-1}	5
Silver		10^{-2}	10
No colour			20

From the above table, the colour code of a given resistor of resistance 3.5 kΩ ± 5% is orange, green, red and gold.

45. (a) : The equivalent circuit is

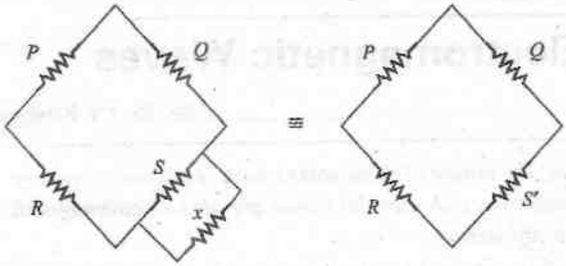


6 Ω and 6 Ω are in parallel.

∴ 3 Ω, 1 Ω and 1 Ω are in series.

∴ Total effective resistance = 5 Ω.

46. (d) : Let x be the resistance shunted with S for the bridge to be balanced.
For a balance Wheatstone's bridge



$$\frac{P}{Q}=\frac{R}{S'} \quad \text{or} \quad \frac{2}{2}=\frac{2}{S'}$$

or $S' = 2\ \Omega$.

From figure, $\frac{1}{S'}=\frac{1}{S}+\frac{1}{x}$ or $\frac{1}{2}=\frac{1}{3}+\frac{1}{x}$

or $\frac{1}{x}=\frac{1}{2}-\frac{1}{3}=\frac{1}{6}$ or $x=6\ \Omega$.

47. (b) : The magnetic field at a point at a distance r from the long straight wire carrying current I is given by

$$B=\frac{\mu_0}{4\pi}\frac{2I}{r} \quad \text{or} \quad B \propto \frac{1}{r}.$$

48. (c) : Given : Energy of proton $E = 2$ MeV

$= 2 \times 1.6 \times 10^{-19} \times 10^{6}$ J

Magnetic field $B = 2.5$ T

Mass of proton $m = 1.6 \times 10^{-27}$ kg

Magnetic force on the proton $\vec{F} = q(\vec{v} \times \vec{B})$

or $F = qvB\sin\theta$ or $F = qvB$ ... (i)

[Given θ = 90°]

Also, $E=\frac{1}{2}mv^2$ or $v=\sqrt{\frac{2E}{m}}$

Substitute in eq. (i), we get

$$F = qB\sqrt{\frac{2E}{m}}$$

$$=1.6\times10^{-19}\times2.5\sqrt{\frac{2\times2\times1.6\times10^{-19}\times10^{6}}{1.6\times10^{-27}}}$$

$= 1.6 \times 10^{-19} \times 2.5 \times 2 \times 10^{7}$

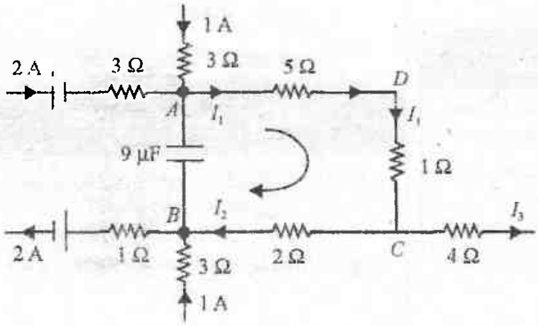
$= 8 \times 10^{-12}$ N.

Thought Provoking Problems in Current Electricity

By : Prof. R.S. Randhawa*

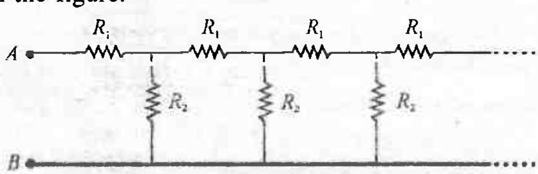
1. The space between two coaxial cylinders, whose radii are a and b (where $a < b$), is filled with conducting medium of conductivity of the medium is σ. Calculate the resistance between the cylinders in the radial direction. (Assuming $L >> b$) where, L is the length of the cylinder.

2. A part of circuit in steady state along with current flowing in the branches, with value of each resistance is shown in figure. Calculate the energy stored in the capacitor C.



3. A potentiometer wire of length 100 cm has a resistance of 9 Ω. It is connected in series with a resistance and accumulator of emf 3 V and of negligible internal resistance. A source of 13 mV is balanced against a length of 60 cm of the potentiometer wire. Find the value of external resistance?

4. Find the effective resistance between A and B of an infinite chain of resistors R_1 and R_2 joined as shown in the figure.



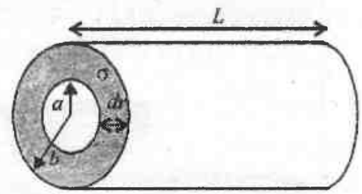
5. How long does it take for current to decay to half its value, while charging? We can consider this time as half-life of the current in a charging series RC circuit.

SOLUTIONS

1. The area through which the current flows across a shell of radius r is

$A(r) = 2\pi rL.$

$\therefore$ The resistance of the shell of radius r is



$$dR = \frac{1}{\sigma}\frac{dr}{2\pi rL}$$

$$\therefore \quad R_{ab} = \int_a^b dR = \frac{1}{2\pi\sigma L}\int_a^b \frac{dR}{R}$$

$$= \frac{1}{2\pi\sigma L}[\ln R]_a^b = \frac{\ln(b/a)}{2\pi\sigma L}.$$

2. From Kirchhoff's Ist law at junctions A and B respectively, we have $\Sigma I = 0$.

$2 + 1 - I_1 = 0.$

$\therefore \quad I_1 = 3$ A

and $I_2 + 1 - 2 = 0.$ i.e. $I_2 = 1$ A

Also, $V_A - 3 \times 5 - 3 \times 1 - 1 \times 2 = V_B$

i.e., $V_A - V_B = 20$ V

$\therefore$ Energy stored in the capacitor,

$$U = \frac{1}{2}C(V_A - V_B)^2$$

$$U = \frac{1}{2} \times (9 \times 10^{-6}) \times (20)^2 = \frac{1}{2} \times 9 \times 10^{-6} \times 400$$

$= 18 \times 10^{-4}$ J.

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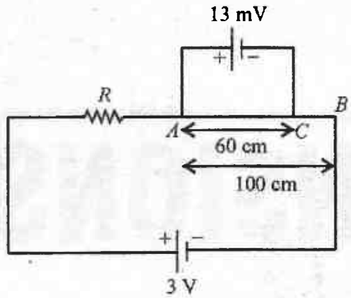
3. 

Potential drop across wire = current × resistance

$$=\left(\frac{3}{R+9}\right)\times 9=\frac{27}{R+9}$$

$\therefore$ The potential drop per cm of the wire is

$$=\frac{27}{(100)(R+9)}\ \text{V cm}^{-1}.$$

The fall of potential across 60 cm of the wire is

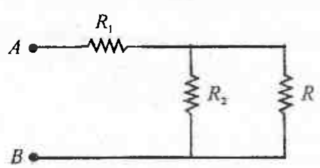
$$=\frac{60\times 27}{100(R+9)}=\frac{16.2}{R+9}$$

which must be equal to the emf of the source when balanced is achieved. Thus

$$\frac{16.2}{R+9}=13\times 10^{-3}\ \Rightarrow\ R+9=\frac{16.2}{13}\times 10^{3}=1246$$

$\Rightarrow$ R = 1237 Ω.

4. The given equivalent network is written as equal to



The original infinite chain is equivalent to R_1 in series with R_2 and R in parallel.

$$R=R_1+\frac{RR_2}{R+R_2}\quad\text{or}\quad R^2-RR_1-R_1R_2=0$$

$$\therefore\quad R=\frac{R_1\pm\sqrt{R_1^2+4R_1R_2}}{2}=\frac{R_1}{2}\left(1+\sqrt{1+\frac{4R_2}{R_1}}\right).$$

(–ve sign is neglected).

5. The current in charging series RC circuit is given by

$$I=I_0e^{-t/RC}$$

When current is halved, $\frac{I_0}{2}=I_0\,e^{-t/RC}$

or, $\frac{1}{2}=e^{-t/RC}$

Taking the natural logarithms on both sides and solving for t,

$$\ln 2=\frac{t}{RC}\quad\text{or}\quad t=RC\ln 2$$

$\therefore$ $t=\tau\,(0.693)$. (Since ln2 = 0.693)

Challenging COMPREHENSIONS

Comprehension-1

A bullet of mass M is fired with a velocity of 50 m/sec, at an angle θ with the horizontal. At the highest point of its trajectory, it collides head on with a bob of mass $3M$ suspended by a massless string of length (10/3) metres and gets embedded in the bob. After the collision, the string moves through an angle of 120°.

1. The angle θ is
(a) 37° (b) 47° (c) 57° (d) 67°.

2. The horizontal coordinate of the initial position of the bob with respect to the point of firing of the bullet (Take g = 10 ms^{-2})
(a) 60 m (b) 120 m (c) 150 m (d) 200 m.

3. The vertical coordinate of the initial position of the bob with respect to the point of firing of the bullet. (Take g = 10 ms^{-2}).
(a) 25 m (b) 35 m (c) 45 m (d) 55 m.

Comprehension-2

A 20 kg body is released from rest so as to slide in between two vertical rails and compresses a vertical spring of force constant k = 1920 N/m placed at a distance of 1.0 m from the starting position of the body. The rail offers a frictional force of 36 N opposing the motion of the body.

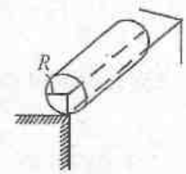
4. The velocity v of the body just before striking with the spring is
(a) 2 m/s (b) 4 m/s (c) 6 m/s (d) 8 m/s.

5. The distance l through which the spring is compressed. Find the value of l
(a) 1 m (b) 0.5 m (c) 2 m (d) 3 m.

6. The distance h' through which the body is rebounded up. Find the value of h'
(a) 0.5 m (b) 1.03 m
(c) 2 m (d) 2.5 m.

Comprehensions-3

A rectangular rigid fixed block has a long horizontal edge. A solid homogeneous cylinder of radius R is placed horizontally at rest with its length parallel to the edge such that the axis of the cylinder and the edge of the block are in the same vertical plane as shown in figure. There is sufficient friction present at the edge so that a very small displacement causes the cylinder to roll of the edge without slipping.



7. The angle θ_c through which the cylinder rotates before it leaves contact with the edge is

(a) $\cos^{-1}\left(\frac{7}{4}\right)$ (b) $\cos^{-1}\left(\frac{4}{7}\right)$

(c) $\sin^{-1}\left(\frac{7}{4}\right)$ (d) $\sin^{-1}\left(\frac{4}{7}\right)$.

8. The speed of the centre of mass of the cylinder before leaving contact with the edge is

(a) $\sqrt{\frac{4}{7}gR}$ (b) $\sqrt{\frac{7}{4}gR}$

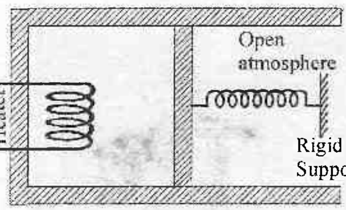
(c) $\sqrt{\frac{10}{7}gR}$ (d) $\sqrt{\frac{7}{4}gR}$.

9. The ratio of the translational to rotational kinetic energies of the cylinder when its centre of mass is in horizontal line with the edge.
(a) 6 (b) 5 (c) 4 (d) 3.

Comprehensions-4

An ideal monoatomic gas is confined in a cylinder by a spring-loaded massless piston of cross-section 8.0×100^{-3} m^2. Initially, the gas is at 300 K and occupies a volume of 2.4×10^{-3} m^3 and the spring is in its relaxed

(unstretched, uncompressed) state. The gas is heated by an electric heater until the piston moves out slowly without friction by 0.1 m. The force constant of the spring is 8000 N/m, atmospheric pressure is 1.0×10^5 Nm^{-2}. The cylinder and the piston are thermally insulated. Gas constant $R = 8.3$ J/mole-K.



10. The final temperature of the gas is
(a) 700 K (b) 800 K
(c) 900 K (d) 1000 K.

11. The heat supplied by the heater is
(a) 620 J (b) 720 J
(c) 820 J (d) 920 J.

Comprehension-5

In a nuclear fusion reactor, the reaction occur in two stages:

(A) Two deuterium ($_1D^2$) nuclei fuse to form a tritium ($_1T^3$) nucleus with a proton as a biproduct. The reaction may be represented as D(D, p)T.

(B) A tritium nucleus fuses with another deuterium nucleus to form a helium ($_2He^4$) nucleus with a neutron as a biproduct. The reaction is represented as T(D, n) α.

Given : $m(_1D^2) = 2.014102$ u
$m(_1T^3) = 3.016049$ u ; $m(_2He^4) = 4.002603$ u
$m(_1H^1) = 1.007825$ u ; $m(_0n^1) = 1.008665$ u

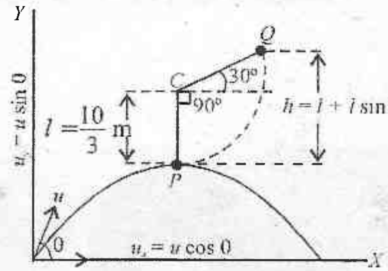
12. The energy released in 1st stage of fusion reaction, is
(a) 4.033 MeV (b) 17.587 MeV
(c) 40.33 MeV (d) 1.7587 MeV.

13. The energy released in the 2nd stage of fusion reaction, is
(a) 4.033 MeV (b) 17.587 MeV
(c) 40.33 MeV (d) 1.7587 MeV.

14. The energy released in the combined reaction per deuterium, is
(a) 4.207 MeV (b) 5.207 MeV
(c) 6. 207 MeV (d) 7.207 MeV.

SOLUTIONS

1. **(a)** : The situation of the problem is shown in figure.



At the highest point of the trajectory of the projectile, the vertical component of the velocity becomes zero, while the horizontal component remains unchanged, *i.e.* $u_y = 0$ and $u_x = u\cos\theta$.

According to law of conservation of linear momentum, we get

$$Mu_x = (M + 3M)v \quad \text{... (i)}$$

where v is the final velocity after the collision. According to principle of conservation of energy,

$$\frac{1}{2}(M + 3M)v^2 = (M + 3M)\,gh$$

or $v^2 = 2gh = 2g\,(l + l\sin 30^\circ)$ ... (ii)

From equation (i),

$$v = \frac{u_x}{4} = \frac{u\cos\theta}{4} = \frac{50\cos\theta}{4} \quad \text{.......(iii)}$$

Substituting this value of v in equation (ii), we get

$$\left(\frac{50\cos\theta}{4}\right)^2 = 2g\,(l + l\sin 30^\circ)$$

or $\cos^2\theta = 2gl\,(1 + \sin 30^\circ)\left(\frac{4}{50}\right)^2$

$$= 2 \times 10 \times \left(\frac{10}{3}\right)\left(1+\frac{1}{2}\right)\left(\frac{4}{50}\right)^2 = 100\times\left(\frac{4}{50}\right)^2$$

$\therefore$ $\cos\theta = 10\times\left(\frac{4}{50}\right) = \left(\frac{4}{5}\right)$ or $\theta = \cos^{-1}\left(\frac{4}{5}\right) = 37^\circ$.

2. **(b)** : Time of ascent,

$$t = \frac{u\sin\theta}{g} = \frac{50\sin 37^\circ}{10} = \frac{50\times 0.6}{10} = 3\text{ sec}$$

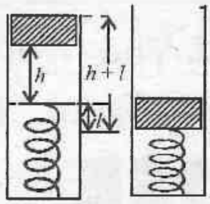
$\therefore$ Horizontal coordinate $x = (u\cos\theta)t$
$= 50 \times 0.8 \times 3 = 120$ m.

3. **(c)** : Vertical coordinate $y = (u\sin\theta)\,t - \frac{1}{2}gt^2$

$= 50 \times 0.6 \times 3 - \frac{1}{2}\times 10\times 9 = 45$ m.

4. **(b)** : Suppose the body slides a distance h against

the frictional force before striking the spring as shown in the figure. Now loss of gravitational potential energy of the body = gain in kinetic energy + Work done against friction



$$mgh = \frac{1}{2}mv^2 + Fh$$

or $\quad 20 \times 9.8 \times 1.0 = \frac{1}{2} \times 20 \times v^2 + 36 \times 1.0$

or $\quad v = 4$ m/sec.

5. (b) : Let l be the maximum compression of the spring as shown in figure. Applying the law of conservation of energy in this position, we get

$$mg(h+l) = \frac{1}{2}kl^2 + F(h+l)$$

or $\quad mgh + mgl = \frac{1}{2}kl^2 + Fh + Fl$

or $\quad \frac{2mgh}{k} + \frac{2mgl}{k} = l^2 + \frac{2Fh}{k} + \frac{2Fl}{k}$

or $\quad l^2 + l\left(\frac{2F}{k} - \frac{2mg}{k}\right) + \left(\frac{2Fh}{k} - \frac{2mgh}{k}\right) = 0$

$$l = \frac{\left(\frac{2mg}{k} - \frac{2F}{k}\right) \pm \sqrt{\left(\frac{2F}{k} - \frac{2mg}{k}\right)^2 - 4\left(\frac{2Fh}{k} - \frac{2mgh}{k}\right)}}{2}$$

Putting the given values and solving, we get $l = 0.5$ m.

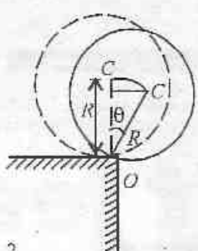
6. (b) : Suppose the spring rebounds to a height h'.

$$\frac{1}{2}kl^2 = mgh' + Fh'$$

or $\quad \frac{1}{2} \times 1920 \times (0.5)^2 = 20 \times 9.8\,h' + 36\,h'$.

Solving we get, $h' = 1.03$ m.

7. (b) : The cylinder rotates about the edge, hence according to law of conservation of energy. Loss in gravitational potential energy = gain in translational kinetic energy + gain in rotational kinetic energy



or $\quad mgR\,[1 - \cos\theta] = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$

$$= \frac{1}{2}mv^2 + \frac{1}{2} \times \left(\frac{1}{2}mR^2\right)(v^2/R^2)$$

or $\quad mgR\,[1 - \cos\theta] = \frac{1}{2}mv^2 + \frac{1}{4}mv^2 + \frac{1}{4}mv^2 = \frac{3}{4}mv^2 \quad \text{... (i)}$

Just before leaving contact, $mg\cos\theta - N = \frac{mv^2}{R}$

At the moment of leaving contact with the edge, $N = 0$

i.e., $mg\cos\theta_c = \frac{mv^2}{R} \quad \text{... (ii)}$

Solving (i) and (ii), we get

$$\cos\theta_c = \frac{4}{7} \quad \text{or} \quad \theta_c = \cos^{-1}\left(\frac{4}{7}\right) \quad \text{... (iii)}$$

8. (a) : Also from (i) and (iii), we get

$$\frac{3}{4}mv^2 = mgR\left[1 - \left(\frac{4}{7}\right)\right] = \frac{3}{7}mgR,$$

$$\therefore v = \sqrt{\frac{4}{7}gR}.$$

9. (a) : At the moment, when cylinder leaves the contact with the edge and its centre of mass is in horizontal line with edge,

K_R = rotational kinetic energy

$$= \frac{1}{2}I\omega^2 = \frac{1}{2} \times \frac{1}{2}mR^2 \times \left(\frac{v}{R}\right)^2 = (1/4)mv^2 = mgR/7$$

Translational kinetic energy according to (i),

$$mgR = K_T + \frac{mgh}{7} \quad \text{or} \quad K_T = \frac{6}{7}mgh$$

$$\therefore \frac{K_T}{K_R} = \frac{(6/7)\,mgR}{mgR/7} = 6.$$

10. (b) : Suppose P_1, V_1, T_1 be the initial pressure, volume and temperature of the gas. Since the spring is initially in relaxed state, $P_1 = 1.0 \times 10^5$ N/m^2 (atmospheric pressure). On being heated, the pressure of the gas increases and the piston is pushed out and the spring is compressed. Suppose the piston moves a distance Δx.

The force exerted on the piston in the compressed state of the spring is given by

$$F = k\Delta x = 8000 \times 0.1 = 800 \text{ N}.$$

If A be the area of cross-section of the piston, then the pressure-increase is

$$\frac{F}{A} = \frac{800 \text{ N}}{8.0 \times 10^{-3} \text{ m}^2} = 1.0 \times 10^5 \text{ N/m}^2$$

The volume-increase of the gas is

$\Delta V = A\Delta x = (8.0 \times 10^{-3}$ m$^2)$ $(0.1$ m$) = 0.8 \times 10^{-3}$ m^3

Now, final pressure, $P_2 = (1.0 \times 10^5) + (1.0 \times 10^5)$
$= 2.0 \times 10^5$ N/m^2

Final volume, $V_2 = (2.4 \times 10^{-3}) + (0.8 \times 10^{-3})$
$= 3.2 \times 10^{-3}\ m^3$.

Let the final temperature of the gas is T_2

From gas law, $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

or $T_2 = \frac{P_2 V_2}{P_1 V_1} \times T_1$

$$= \frac{(2.0 \times 10^5)(3.2 \times 10^{-3})}{(1.0 \times 10^5)(2.4 \times 10^{-3})} \times 300 = 800\ \text{K}.$$

11. (b) : Heat supplied by the heater is used in compressing the spring, in raising the temperature of the gas and in moving the piston.

Work done in compressing the spring is

$$W_1 = \frac{1}{2}kx^2 = \frac{1}{2} \times 8000 \times (0.1)^2 = 40\ \text{J}$$

Number of mole of the gas

$$n = \frac{PV}{RT} = \frac{(1.0 \times 10^5) \times 2.4 \times 10^{-3}}{(8.3) \times (300)} = \frac{8}{83}$$

$\therefore$ Heat supplied for in increasing the temperature or internal energy of the gas

$$W_2 = nC_V \Delta T = n\frac{3}{2}R\,\Delta T = \frac{8}{83} \times \frac{3}{2} \times 8.3 \times 500$$

Work done in moving the piston $= W_3 = F\Delta x$
$= 800 \times 0.1 = 80$ J

$\therefore$ Total heat supplied $= W_1 + W_2 + W_3$
$= 40 + 600 + 80 = 720$ joule.

12. (a) : The first stage reaction may be represented as

$${}_1D^2 + {}_1D^2 \rightarrow {}_1T^3 + {}_1p^1 + Q_1$$

Mass defect, $\Delta m = 2(2.014102) - (3.016049 + 1.007825)$
$= 0.00433$ u

$\therefore$ $Q_1 = 0.00433\ \text{u} \times 931.5\ \text{MeV/u} = 4.033$ MeV.

13. (b) : Now, the reaction for the second stage is

$${}_1T^3 + {}_1D^2 \rightarrow {}_2He^4 + {}_0n^1 + Q_2$$

$\therefore \Delta m = (3.016049 + 2.014102) - (4.002603 + 1.008665)$
$= 0.01888$ u

$\therefore$ $Q_2 = 0.01888\ \text{u} \times 931.5\ \frac{\text{MeV}}{\text{u}} = 17.587$ MeV.

14. (d) : Total energy released $= Q_1 + Q_2$
$= 4.033 + 17.587 = 21.62$ MeV

$\therefore$ Energy released/deuteron $= \frac{21.62}{3} = 7.207$ MeV .

■

AIIMS | CBSE | DPMT | AFMC | VMMC | EAMCET | WB-JEE | BHU | CMC

2007 Medical Entrance Exam

UP CPMT | Manipal PMT

Practice Test Paper

CET Karnataka | JIPMER

MP PMT | MGIMS | PMDT Bihar | PMT Haryana | Kerala PMT | Raj. PMT | TNPCEE

1. A force F is given by $F = at + bt^2$, where t is time. What are dimensional formulae of a and b?
(a) MLT^{-3} and ML^2T^4 (b) MLT^{-3} and MLT^{-4}
(c). MLT^{-1} and MLT^0 (d) MLT^{-4} and MLT^1

2. A motorist travels A to B at a speed at 40 km/h and returns at speed of 60 km/h. His average speed will be
(a) 40 km/h (b) 48 km/h
(c) 50 km/h (d) 60 km/h.

3. A ball of mass m moving with uniform speed collides elastically with another stationary ball. The incident ball will lose maximum kinetic energy when mass of the stationary ball is
(a) m (b) $2m$
(c) $4m$ (d) infinity.

4. A particle is dropped vertically from rest, from a height. The time taken by it to fall through successive distances of 1 m each will then be
(a) all equal, being equal to $\sqrt{2/g}$ second
(b) in the ratio of the square roots of the integers 1, 2, 3,....
(c) in the ratio of the difference in the square roots of integers *i.e.*
$\sqrt{1}, (\sqrt{2}-\sqrt{1}), (\sqrt{3}-\sqrt{2}), (\sqrt{4}-\sqrt{3})$.................
(d) in the ratio of the reciprocals of square roots of the integers *i.e.* $\frac{1}{\sqrt{1}}, \frac{1}{\sqrt{2}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{4}}$.

5. A body of mass 2 kg is released from rest at the top of the smooth inclined plane having inclination 30°. It takes 3 s to reach the bottom. If the angle of inclination is doubled, what will be the time taken to reach the bottom?
(a) 3 s (b) $\sqrt{3}$ s
(c) $(1/\sqrt{3})$ s (d) none of these.

6. A boy having a mass of 60 kg holds in hand a school bag of weight 40 N. With what force the floor will push up on his feet (g = 10 m/s²)?
(a) 100 N (b) 600 N
(c) 640 N (d) 64 N

7. A horizontal force, just sufficient to move a body of mass 4 kg lying on a rough horizontal surface, is applied on it. The coefficients of static and kinetic friction between the body and the surface are 0.8 and 0.6 respectively. If the force continues to act even after the block has started moving, the acceleration of the block in metres per sec² is (g = 10 m/s²)
(a) 1/4 (b) 1/2
(c) 2 (d) 4.

8. 250 N force is required to raise 75 kg mass with a system of pulleys. If rope is pulled 12 m then the load is lifted to 3 m, the efficiency of pulley system will be
(a) 25% (b) 33.3%
(c) 75% (d) 90%.

9. A ball is dropped from a height of 20 cm. Ball rebounds to a height of 10 cm. What is the loss of energy?
(a) 25% (b) 75%
(c) 50% (d) 100%

10. A child is standing with folded hands at the center of a platform rotating about its central axis. The kinetic energy of the system is K. The child now stretches his arms so that the moment of inertia of the system doubles. The kinetic energy of the system now is
(a) $2K$ (b) $\frac{K}{2}$
(c) $\frac{K}{4}$ (d) $4K$.

11. One solid sphere A and another hollow sphere B are of same mass and same radii. Their moment of inertia about their diameters are respectively I_A and I_B such that
(a) $I_A = I_B$ (b) $I_A > I_B$
(c) $I_A < I_B$ (d) $\frac{I_A}{I_B} = \frac{d_A}{d_B}$
where d_A and d_B are their densities.

12. A satellite A of mass m is at distance of r from the surface of the earth. Another satellite B of mass $2m$ is at a distance of $2r$ from the earth's surface. Their time periods are in the ratio of
(a) 1 : 2 (b) 1 : 16
(c) 1 : 32 (d) 1 : $2\sqrt{2}$

13. The escape velocity of a body on the surface of the earth is 11.2 km/s. If the earth's mass becomes twice its present value and the radius of the earth becomes half, the escape velocity would become
(a) 5.6 km/s (b) 11.2 km/s
(c) 22.4 km/s (d) 44.8 km/s.

14. The reading of a spring balance when a block is suspended from it in air is 60 N. This reading is changed to 40 N when the block is submerged in water. The specific gravity of the block will be
(a) 3/2 (b) 6
(c) 2 (d) 3

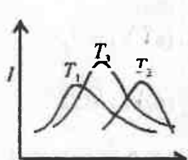
15. A solid of relative density D is floating in a liquid of density d. If v be the volume of solid submerged in the liquid and V be the total volume of the solid. Then
(a) $vd = (1 + D)V$ (b) $\frac{V}{v} = \frac{D}{d}$
(c) $\frac{v}{V} = \frac{D}{d}$ (d) $DV = (1 + d)v$

16. Terminal velocity depends on radius of drop r and viscosity η according to
(a) $v_T \propto r\eta$ (b) $v_T \propto r^2\eta$
(c) $v_T \propto \frac{\eta}{r^4}$ (d) $v_T \propto \frac{r^2}{\eta}$.

17. Real gases obey ideal gas laws more closely at
(a) high pressure and low temperature
(b) low pressure and high temperature
(c) high pressure and high temperature
(d) low pressure and low temperature.

18. The equation of state of 5 g of oxygen gas at a pressure P and temperature T, when occupying a volume V, will be
(a) $PV = 5\,RT$ (b) $PV = (5/2)\,RT$
(c) $PV = (5/16)\,RT$ (d) $PV = (5/32)\,RT$.

19. The plots of intensity versus wavelength for three black bodies at temperature T_1, T_2 and T_3 respectively are as shown in the figure. Their temperatures are such that



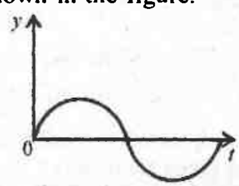
(a) $T_1 > T_2 > T_3$ (b) $T_1 > T_3 > T_2$
(c) $T_2 > T_3 > T_1$ (d) $T_3 > T_2 > T_1$.

20. 100 g ice at 0°C is mixed with 100 g water at 20°C. The temperature of mixture will be
(a) –30°C (b) –20°C
(c) –10°C (d) 0°C.

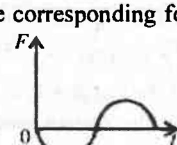
21. The efficiency of a Carnot engine operating with reservoir temperature of 100°C and –23°C will be
(a) $\frac{100-23}{373}$ (b) $\frac{100+23}{373}$
(c) $\frac{100+23}{100}$ (d) $\frac{100-23}{100}$

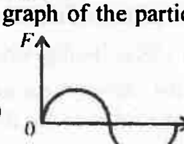
22. The total energy of a particle, executing simple harmonic motion is
where x is the displacement from the mean position.
(a) $\propto x$ (b) $\propto x^2$
(c) independent of x (d) $\propto \sqrt{x}$.

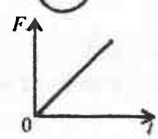
23. The displacement time graph of a particle executing S.H.M. is as shown in the figure.

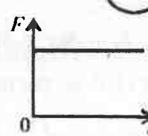


The corresponding force-time graph of the particle is

(a)


(b)


(c)


(d)


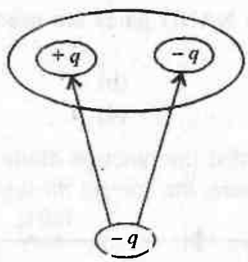
24. Two wave of wavelengths 99 cm and 100 cm both travelling with velocity 396 m/s are made to interfere. The number of beats produced by them per second are
(a) 1 (b) 2
(c) 4 (d) 8.

25. An earthquake generates both transverse (S) and longitudinal (P) sound waves in the earth. The speed of S waves is about 4.5 km/s and that of P waves is about 8.0 km/s. A seismograph records P and S waves from from an earthquake. The first P wave arrives 4.0 min before the first S wave. The epicenter of the earthquake is located at a distance of about

(a) 25 km (b) 250 km
(c) 2500 km (d) 5000 km.

26. If fundamental frequency of closed pipe is 50 Hz then frequency of 2nd overtone is
(a) 100 Hz (b) 50 Hz
(c) 250 Hz (d) 150 Hz

27. Shown below is a distribution of charges. The flux of electric field due to these charges through the surface is

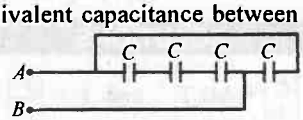


(a) $3q/\varepsilon_0$ (b) $2q/\varepsilon_0$
(c) q/ε_0 (d) zero.

28. Two plates are 1 cm apart and potential difference between them is 10 volt. The electric field between the plates is
(a) 10 V/m (b) 500 V/m
(c) 10^3 V/m (d) 250 V/m.

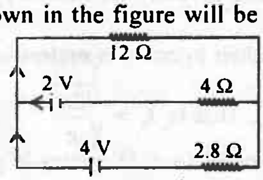
29. The radius of nucleus of silver (atomic number = 47) is 3.4×10^{-14} m. The electric potential on the surface of nucleus is ($e = 1.6 \times 10^{-19}$ C)
(a) 1.99×10^6 volt (b) 2.9×10^6 volt
(c) 4.99×10^6 volt (d) 0.99×10^6 volt.

30. The equivalent capacitance between A and B is



(a) $\frac{C}{4}$ (b) $\frac{3C}{4}$
(c) $\frac{C}{3}$ (d) $\frac{4C}{3}$

31. The steady state current through 12 Ω resistance in the circuit shown in the figure will be



(a) zero (b) 1 amp
(c) 0.6 amp (d) none of these

32. A piece of metal weighing 200 g is to be electroplated with 5% of its weight in gold. If the strength of available current is 2 ampere, how long would it take deposit the required amount of gold? [E.C.E of hydrogen is 0.1044×10^{-4} g/C, At. wt. of gold = 197.1, At. wt of hydrogen = 1.008]
(a) 1.02 h (b) 2.04 h
(c) 4.08 h (d) 8.04 h

33. A straight wire of diameter 0.5 mm carrying a current of 1 A is replaced by another wire of 1 mm diameter carrying the same current. The strength of magnetic field far away is
(a) twice the earlier value
(b) half of the earlier value
(c) quarter of its earlier value
(d) unchanged.

34. An ion enters in perpendicular direction in a uniform magnetic field of 4×10^{-2} Wb/m² with the velocity of 2×10^5 m/s. The specific charge of $\left(\frac{q}{m}\right)$ of ion = 5×10^7 coulomb/kg, then the radius of its circular path will be
(a) 0.10 m (b) 0.40 m
(c) 0.20 m (d) 0.25 m

35. A moving coil galvanometer has a resistance of 900 Ω. In order to obtain only 10% of the main current through this galvanometer, the resistance of the required shunt is
(a) 0.9 Ω (b) 100 Ω
(c) 405 Ω (d) 90 Ω.

36. A fuse wire is having 5 ampere current rating. What is the peak value of current it can have?
(a) 0.7074 A (b) 7.07 A
(c) 0.0707 A (d) 7.707 A

37. In a uniform magnetic field of induction B a wire in the form of a semicircle of radius r rotates about the diameter of the circle with an angular frequency ω. The axis of rotation is perpendicular to the field. If the total resistance of the circuit is R the mean power generated per period of rotation is

(a) $\frac{B\pi r^2 \omega}{2R}$ (b) $\frac{(B\pi r^2 \omega)^2}{8R}$
(c) $\frac{(B\pi r\omega)^2}{2R}$ (d) $\frac{(B\pi r\omega^2)^2}{8R}$

38. In an electromagnetic wave the average energy

density associated with the electric field is given by

(a) $\frac{1}{2}\frac{E^2}{\varepsilon_0}$ (b) $\frac{1}{2}\varepsilon_0 E^2$

(c) $\frac{1}{2}\frac{E}{\varepsilon_0}$ (d) $\frac{1}{2}E\varepsilon_0$.

39. In order to obtain a real image of magnification 2 using a converging lens of focal length 20 cm, where should be an object be placed?
(a) 50 cm (b) 40 cm
(c) –50 cm (d) –30 cm

40. A beam of light of wavelength 600 nm from a source falls on a single slit 1 mm wide and the resulting diffraction pattern is observed on a screen 2 m away. The distance between the first dark fringes on either side of the central bright fringe is
(a) 2.4 cm (b) 2.4 mm
(c) 1.2 mm (d) 1.2 cm.

41. The resolving power of a reflecting telescope depends
(a) on the intensity of light used
(b) directly on wavelength of the light used
(c) on the focal length of objective lens
(d) directly on the diameter of objective lens

42. Two thin lenses of powers 12 D and –2 D respectively are placed in contact, the power, focal length and nature respectively will be
(a) 8 D, 0.8 m, convex (b) 14 D, 0.5 m, convex
(c) 5 D, 0.2 m, convex (d) 10 D, 0.1 m, convex.

43. Brilliance of diamond is due to
(a) shape (b) cutting
(c) reflection (d) total internal reflection.

44. A radioactive element has half-life period 1600 years. After 6400 years what amount will remain?
(a) 1/2 (b) 1/16
(c) 1/8 (d) 1/4

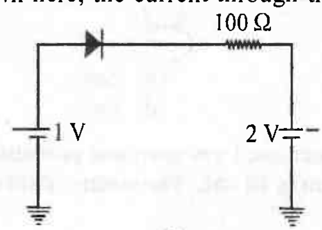
45. In a hypothetical Bohr hydrogen, the mass of the electron is doubled. The energy E_0 and the radius r_0 of the first orbit will be (a_0 is the Bohr radius)
(a) $E_0 = -27.2$ eV; $r_0 = a_0/2$
(b) $E_0 = -27.2$ eV; $r_0 = a_0$
(c) $E_0 = -13.6$ eV; $r_0 = a_0/2$
(d) $E_0 = -13.6$ eV; $r_0 = a_0$.

46. Photoelectric work function of a metal is 1 eV. Light of wavelength 3000 Å falls on it. The photoelectrons come out with velocity
(a) 10 metre per second (b) 10^3 metre per second
(c) 10^4 metre per second (d) 10^6 metre per second

47. A proton and an alpha particle are accelerated through a potential difference of 100 V. The ratio of the wavelength associated with the proton to that associated with an alpha particle is
(a) $\sqrt{2}$ (b) 2
(c) $2\sqrt{2}$ (d) $\frac{1}{2\sqrt{2}}$

48. How many NAND gates are used to form AND gate?
(a) 1 (b) 2
(c) 3 (d) 4.

49. Assuming that the junction diode is ideal, in the circuit shown here, the current through the diode is



(a) zero (b) 1 mA
(c) 10 mA (d) 30 mA.

50. A T.V. tower has a height of 200 m. How much population is covered by T.V. broadcast, it the average population density around the tower is 1200 km^{-2}? (Radius of earth, $R = 6.4 \times 10^6$ m)
(a) 6×10^6 (b) 2×10^6
(c) 12×10^6 (d) 9×10^6.

SOLUTIONS

1. (b) : $a = \left[\frac{F}{t}\right] = \text{MLT}^{-3}$ and $b = \left[\frac{F}{t^2}\right] = \text{MLT}^{-4}$

2. (b) : $v = \frac{2x}{\frac{x}{40}+\frac{x}{60}} = \frac{2\times 40\times 60}{60+40} = 48 \text{ km h}^{-1}$

3. (a) : Loss of kinetic energy is maximum when balls are of equal mass. In such a case the first ball will come to rest.

4. (c) : Time taken to cover n metres is given by

$$n = \frac{1}{2}gt_n^2. \text{ That is } t_n = \sqrt{\frac{2n}{g}}$$

Time taken to cover $(n + 1)$ metres is given by

$$t_{n+1} = \sqrt{\frac{2(n+1)}{g}}$$

$$t_{n+1} - t_n = \sqrt{\frac{2(n+1)}{g}} - \sqrt{\frac{2n}{g}} = \sqrt{\frac{2}{g}}\left[\sqrt{n+1} - \sqrt{n}\right]$$

This given ratio as :

$\sqrt{1}, \sqrt{2} - \sqrt{1}, \sqrt{3} - \sqrt{2}$ and so on.

5. (b) : Time taken by a body to reach the bottom of an smooth inclined plane is given by

$$t = \sqrt{\frac{2l}{g\sin\theta}}$$

where l is the length of an inclined plane, θ is the angle of inclination.

Since l, g remains the same

$$\therefore t \propto \sqrt{\frac{1}{\sin\theta}} \quad \text{or} \quad \frac{t_1}{t_2} = \sqrt{\frac{\sin\theta_2}{\sin\theta_1}}$$

or $$t_2 = t_1\sqrt{\frac{\sin\theta_1}{\sin\theta_2}} = 3\sqrt{\frac{\sin 30°}{\sin 60°}} = 3\sqrt{\frac{(1/2)}{(\sqrt{3}/2)}}$$

$$t_2 = \frac{3}{\sqrt{3}} = \sqrt{3}\text{ s.}$$

6. (c) : Total force on the floor due to boy and school bag is given by

F = weight of boy + weight of bag

or F = (Mass of boy) × g + weight of bag,

i.e. $F = Mg + W$

Substituting $M = 60$ kg; $g = 10$ ms^{-2}; $W = 40$ N, we get $F = 640$ N

7. (c) : $F - f_k = ma$

or $\mu_s mg - \mu_k mg = ma$ or $a = (\mu_s - \mu_k)g$

or $a = (0.8 - 0.6)\,10 = 2$ ms^{-2}

8. (c) : Efficiency of pulley (η) $= \frac{\text{Output}}{\text{Input}} = \frac{75 \times 10 \times 3}{250 \times 12}$
$= 0.75 = 75\%$.

9. (c) : Potential energy due to height h is given by

$$U = mgh \Rightarrow U \propto h \Rightarrow \frac{U'}{U} = \frac{h'}{h}$$

Substituting $h' = 10$ cm; $h = 20$ cm, we get

$$\frac{U'}{U} = \frac{1}{2} \Rightarrow U' = \frac{U}{2}$$

Hence, percentage loss of energy is given by

$$\frac{U - U'}{U} \times 100 = \frac{U - U/2}{U} \times 100 = 50\%$$

10. (b) : The rotational kinetic energy is given by

$K = (1/2)I\omega^2$ ....(i)

Here, I = moment of inertia, ω = angular velocity

Also from law of conservation of angular momentum, we have

$I\omega$ = constant

If moment of inertia is doubled, angular velocity will be halved to keep the product constant.

So, we have, $I' = 2I$, $\omega' = \omega/2$

Hence, kinetic energy of the system becomes

$$K' = \frac{1}{2}I'\omega'^2 = \frac{1}{2}(2I)\left(\frac{\omega}{2}\right)^2 = \frac{1}{2}\left(\frac{1}{2}I\omega^2\right)$$

Using equation (i), we have $K' = \frac{K}{2}$

11. (c) : Moment of inertia of a solid sphere about diameter is given by

$I_A = (2/5)\,mR^2$ or $I_A = 0.4mR^2$ ....(i)

Moment of inertia of a hollow sphere about diameter is given by

$I_B = (2/3)mR^2$ or $I_B = 0.6\,mR^2$ ....(ii)

From (i) and (ii), we get $I_A < I_B$

12. (d) : Time period does not depend on the mass. Also $T^2 \propto r^3$.

$$\therefore \frac{T_A}{T_B} = \left(\frac{r_A}{r_B}\right)^{3/2} = \left(\frac{r}{2r}\right)^{\frac{3}{2}} = \frac{1}{2\sqrt{2}}$$

13. (c) : Escape velocity $v_{es} = \sqrt{2gR} = \sqrt{2GM/R}$

$v'_{es} = \sqrt{2 \times G \times (2M)/(R/2)} = 2\sqrt{2GM/R} = 2v_{es}$

14. (d) : Relative density = specific gravity

$$= \frac{\text{Weight in air}}{\text{Loss of weight in water}}$$

$$\text{specific gravity} = \frac{60\text{ N}}{60\text{ N} - 40\text{ N}} = \frac{60}{20} = 3$$

15. (c) : Weight of the body = Weight of the liquid displaced

$VDg = vdg$. Hence $\frac{v}{V} = \frac{D}{d}$

16. (d) **17. (b)**

18. (d) : From ideal gas equation, we have

$PV = nRT$ ...(1)

where n is the number of moles of the gas and is given by

$$n = \frac{\text{given mass}}{\text{molecular mass of } O_2} = \frac{m}{M}$$

$$n = \frac{5}{32}$$

Hence, equation (i) becomes $PV = \frac{5}{32}RT$.

19. (b) : According to Wein's displacement law,

$\lambda_m T$ = constant

Therefore we can conclude that higher the value of λ_m smaller the value of temperature.

Therefore, $T_1 > T_3 > T_2$.

20. (d) : The heat supplied by the hot water = 100 × 20 = 2000 cal.
The heat supplied is very small as compared to heat required by 100 g ice (8000 cal) to melt. Because only some ice is melted, the temperature is 0°C.

21. (b) : Efficiency of Carnot engine is given by

$$\eta = 1 - \frac{T_2}{T_1}$$

Given T_1 = 100°C = 100 + 273 = 373 K

T_2 = –23°C = – 23 + 273 = 250 K

$$\therefore \eta = 1 - \frac{250}{373} = \frac{123}{373} = \frac{100+23}{373}$$

22. (c) : The total energy of simple harmonic motion is given by

$E = \frac{1}{2} m\omega^2 A^2$ where A = amplitude of S.H.M.

In S.H.M., as a particle is displaced from its mean position, its kinetic energy is converted to potential energy and vice versa. As a result, the total energy of S.H.M. remains constant. Hence, the total energy of S.H.M. is independent of displacement x.

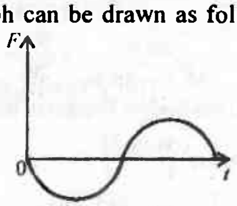
23. (a) : In S.H.M., force is given by

$$F = ma = -m\omega^2 y$$

Now, when $y = 0$; $F = 0$

And when $y = A$; $F = -m\omega^2 A$. i.e force is maximum but in opposite direction of displacement.

Hence, the graph can be drawn as follows :



24. (c) : Number of beats is given by $n = \upsilon_1 - \upsilon_2$

or $n = \frac{v}{\lambda_1} - \frac{v}{\lambda_2}$ or $n = v\left[\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right]$

Substituting v = 396 ms^{-1}; λ_1 = 99 cm = 0.99 m; λ_2 = 100 cm = 1m, we get n = 4.

25. (c) : Let the distance of the epicenter of the earthquake be x.

Time taken by S wave, $t_1 = \frac{x}{4.5}$ s .....(i)

Time taken by P wave, $t_2 = \frac{x}{8.0}$ s ....(ii)

According to question, $t_1 - t_2 = 4 \times 60$

or $\frac{x}{4.5} - \frac{x}{8} = 4 \times 60$ [using (i) and (ii)]

On solving, we get $x \sim 2500$ km

26. (c) : In a closed end organ pipe, we have

$\upsilon_1 : \upsilon_3 : \upsilon_5 :$ .... = 1 : 3 : 5 : ....

⇒ IInd overtone = 5th harmonic

= 5 × fundamental frequency

i.e, $\upsilon_5 = 5\,\upsilon_1$

Substituting υ_1 = 50 Hz, we get

υ_5 = 5 × 50 = 250 Hz.

27. (d) : According to Gauss's theorem, total electric flux through any closed surface is equal to $\frac{1}{\varepsilon_0}$ times the total charge enclosed by the surface *i.e.*,

$$\phi = \frac{q}{\varepsilon_0} = \frac{+q-q}{\varepsilon_0} = 0$$

Note that charges situated outside the closed surface are not considered to total electric flux.

28. (c) : $E = \frac{V}{d} = \frac{10}{10^{-2}} = 10^3\ \text{Vm}^{-1} = 10^3\ \text{NC}^{-1}$.

29. (a) : Potential at the surface of the nucleus is given by $V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$

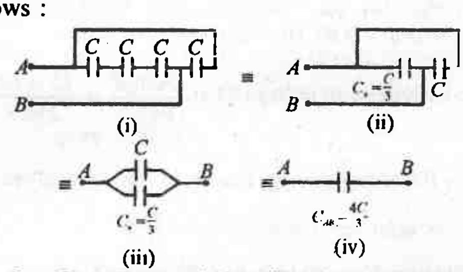
Charge on the nucleus, $q = Ze$

So, we have $V = \frac{1}{4\pi\varepsilon_0}\frac{Ze}{r}$

Substituting Z = 47; e = 1.6 × 10^{-19} C; r = 3.4 × 10^{-14} m, we get

$$V = \frac{9\times10^9\times47\times1.6\times10^{-19}}{3.4\times10^{-14}} = 1.99 \times 10^6\ \text{V}.$$

30. (d) : The given circuit diagram can be simplified as follows :



It is clear from figure (i) that first three capacitors are in series.

Hence, equivalent capacitance of series combination is given by

$$\frac{1}{C_S} = \frac{1}{C} + \frac{1}{C} + \frac{1}{C} = \frac{3}{C} \Rightarrow C_S = \frac{C}{3}$$

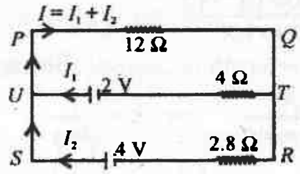
Now, from figure (ii), it is clear that C_S and C both are in parallel

Hence, the circuit can be simplified as shown in figure (iii).

Further, equivalent capacitance of parallel combination is given by :

$$C_{AB} = \frac{C}{3} + C = \frac{4C}{3}.$$

31. (d) : Applying Kirchhoff's loop rule in the given circuit diagram, we have



For loop $PQRS$, $4 = 2.8\, I_2 + 12I$

or $4 = 2.8\, I_2 + 12\,(I_1 + I_2)$

or $4 = 12\, I_1 + 14.8\, I_2$ ....(i)

For loop $PQTU$

$2 = 4\, I_1 + 12I$

or $2 = 4\, I_1 + 12\,(I_1 + I_2)$

or $2 = 16\, I_1 + 12\, I_2$ ....(ii)

On solving (i) and (ii), we get

$I_2 = 0.43$ A

Substituting the value of I_2 in equation (ii), we get

$I_1 = -0.19$ A

Hence, current through 12 Ω resistor is given by

$I = I_1 + I_2 = -0.19 + 0.43 = 0.24$ A

32. (b) : The mass of gold to be deposited on the metal is given by

$$m = \frac{5}{100} \times 200 = 10\,\text{g}.$$

According to Faraday's first law of electrolysis,

$$m = ZIt \Rightarrow t = \frac{m}{ZI}$$

Here $m = 10, I = 2 \Rightarrow t = \dfrac{10}{Z_{Au} \times 2}$ ....(i)

Electrochemical equivalent $= \dfrac{\text{Chemical equivalent}}{\text{Faraday's constant}}$

But chemical equivalent $= \dfrac{\text{Atomic weight}}{\text{Valency}}$

$\Rightarrow$ Electrochemical equivalent

$$= \frac{\text{Atomic weight}}{\text{Valency} \times \text{Faraday's constant}}$$

$$\Rightarrow \frac{Z_{Au}}{Z_H} = \left[\frac{197.1}{3}\right] \times \left[\frac{1}{1.008}\right].$$

Substituting $Z_H = 0.1044 \times 10^{-4}$ g/C, we get

$Z_{Au} = 6.8 \times 10^{-4}$ g/C ...(ii)

$$t = \frac{10}{Z_{Au} \times 2} = \frac{10}{6.8 \times 10^{-4} \times 2} = 7352.9 \text{ sec} = 2.04 \text{ h}.$$

33. (d) : The magnetic field at a point due to long linear current carrying wire is given by

$$B = \frac{\mu_0}{4\pi}\frac{2I}{r}$$

It is independent of the radius of the wire.

34. (a) : In a magnetic field, perpendicular to velocity of particle.

$$\frac{mv^2}{r} = Bqv \quad \text{or} \quad r = \frac{mv}{Bq}$$

$$r = \frac{v}{B\left(\frac{q}{m}\right)} = \frac{2 \times 10^5}{4 \times 10^{-2} \times 5 \times 10^7} = 0.1 \text{ m}$$

35. (b) : Total current is I. Then $0.1I$ will pass through galvanometer and $0.9I$ will only pass through the shunt resistance as both are in parallel, equating potential drops $0.1I \times G = 0.9I \times S$, therefore

$$\therefore\ S = \frac{G \times 0.1I}{0.9I} = \frac{900 \times 0.1I}{0.9I} = 100\,\Omega$$

36. (b) : Relation between r.ms value and peak value of current is given by

$$I_{rms} = \frac{I_0}{\sqrt{2}}.$$

Given that $I_{rms} = 5$A, substituting it, we get

$I_0 = 5\sqrt{2}$ or $I_0 = 7.07$ A

37. (b) : Magnetic flux is given by

$$\phi = \vec{B}.\vec{A} = BA\cos\theta$$

Substituting $A = \dfrac{\pi r^2}{2}$ (for a semicircle); $\theta = \omega t$,

we get $\phi = \dfrac{B\pi r^2}{2}\cos\omega t$

Now, induced emf is given by

$$\varepsilon = \frac{-d\phi}{dt} = -\frac{d}{dt}\left(\frac{B\pi r^2}{2}\cos\omega t\right)$$

On differentating, we get

$$\varepsilon = \frac{1}{2}B\pi r^2\omega\sin\omega t \quad ....(i)$$

Power is given by

$$P = \frac{\varepsilon^2}{R} = \frac{B^2\pi^2 r^4\omega^2\sin^2\omega t}{4R} \quad \text{(using (i))}$$

Substituting the mean value of $\sin^2\omega t$, i.e.

$\langle \sin^2\omega t \rangle = \dfrac{1}{2}$, we get $P = \dfrac{(B\pi r^2\omega)^2}{8R}$

38. (b)

39. (d) : For real image, $m = \dfrac{v}{u} = -2$

or $v = -2u$

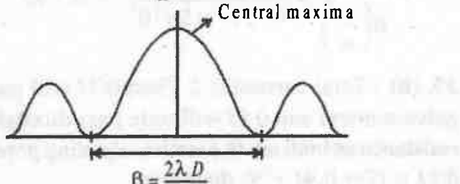
According to lens formula, $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

$$\frac{-1}{2u}-\frac{1}{u}=\frac{1}{20} \qquad (\because f=+20 \text{ cm})$$

$$\frac{-3}{2u}=\frac{1}{20} \quad \text{or} \quad u=-30 \text{ cm}$$

40. (b) : In a diffraction pattern, central maximum is twice as wide as any other secondary maximum or minimum.

Therefore, we have $\beta=\frac{2\lambda D}{a}$ (where a is the width of slit)



Substituting λ = 600 nm = 600 × 10^{-9} m;
D = 2 m; a = 1 mm = 1 × 10^{-3} m, we get

$$\beta=\frac{2\times600\times10^{-9}\times2}{10^{-3}} = 2400\times10^{-6} \text{ m} = 2.4 \text{ mm}.$$

41. (d) : Resolving power of a reflecting type telescope is given by

$$\text{Resolving power}=\frac{D}{1.22\lambda} \Rightarrow \text{Resolving power} \propto D$$

⇒ Resolving power of a reflection telescope depends directly on the diameter of objective lens.

42. (d) : Power of the combination of lenses is given by

$$P=P_1+P_2$$

Substituting P_1 = 12 D; P_2 = – 2 D, we get, P = 10 D
Further, focal length is given by

$$f=\frac{1}{P}=\frac{1}{10}=0.1 \text{ m}.$$

Since the focal length is positive, Therefore the combined lens will be convex lens.

43. (d) : Brilliance of diamond is due to total internal reflection.

44. (b) : $\frac{N}{N_0}=\left(\frac{1}{2}\right)^n$ where n is the number of half-lives

$$\therefore \frac{N}{N_0}=\left(\frac{1}{2}\right)^{\frac{t}{T_{1/2}}}=\left(\frac{1}{2}\right)^{\frac{6400}{1600}}=\left(\frac{1}{2}\right)^4=\frac{1}{16}$$

45. (a) : Here radius of electron orbit $r \propto 1/m$. And energy $E \propto m$, where m is the mass of the electron.

46. (d) : According to Einstein's photo electric equation

$$\frac{hc}{\lambda}=\phi_0+\frac{1}{2}mv^2 \qquad (\text{where } \phi_0 \text{ is the work function})$$

$$\therefore \frac{6.63\times10^{-34}\times3\times10^8}{3000\times10^{-10}}=1.6\times10^{-19}+\frac{1}{2}mv^2$$

$$6.63\times10^{-19}=1.6\times10^{-19}+\frac{1}{2}mv^2$$

$$\frac{1}{2}mv^2=5.03\times10^{-19}$$

$$\text{or} \quad v^2=\frac{5.03\times10^{-19}\times2}{9.1\times10^{-31}} \qquad \therefore v=10^6 \text{ m/s}$$

47. (c) : Wavelength of charged particle is given by

$$\lambda=\frac{h}{\sqrt{2mqV}} \quad \Rightarrow \lambda \propto \frac{1}{\sqrt{mq}}$$

$$\Rightarrow \frac{\lambda_p}{\lambda_\alpha}=\frac{\frac{1}{\sqrt{me}}}{\frac{1}{\sqrt{(4m)(2e)}}}=2\sqrt{2}$$

48. (b) : Two NAND are used to form AND gate

$$Y=\overline{\overline{A\cdot B}}=A\cdot B.$$

49. (a) : The diode is reverse biased, so the current through it is zero.

50. (d) : Here, h = 200 m, R = 6.4 × 10^6 m
Population density ρ = 1200 km^{-2}, ρ = 1200 × 10^{-6} m^{-2}
Population covered = $\rho \times \pi d^2 = \rho \times \pi\,(2hR)$
= 1200 × 10^{-6} × 3.14 × 2 × 200 × 6.4 × 10^6 = 9 × 10^6.

AIIMS | CBSE | DPMT | AFMC | VMMC | EAMCET | WB-JEE | BHU | CMC

2007 Medical Entrance Exam

UP CPMT | CET Karnataka | Manipal PMT | JIPMER

Practice Test Paper

MP PMT | MGIMS | PMDT Bihar | PMT Haryana | Kerala PMT | Raj. PMT | TNPCEE

1. Which of the following group have different dimensions?
(a) Potential difference, EMF, voltage
(b) Pressure, stress, Young's modulus
(c) Heat, energy, work done
(d) Dipole moment, electric flux, electric field.

2. A force F makes an angle 20° with another force F. The resultant of two forces is
(a) $F\cos 20°$ (b) $2F\cos 20°$
(c) $2F\cos 10°$ (d) $F\cos 10°$.

3. A car moves a distance of 200 m. It covers the first half of the distance at speed 40 km/h and the second half of distance at speed v. The average speed is 48 km/h. Find the value of v.
(a) 56 km/h (b) 60 km/h
(c) 50 km/h (d) 48 km/h.

4. The distance covered by a body moving along X-axis with initial velocity u and uniform acceleration a is given by

$$s = ut + \frac{1}{2}at^2$$

This result is a consequence of
(a) newton's III law (b) newton's II law
(c) newton's I law (d) none of these.

5. A food packet is released from a helicopter flying at a height of 1 km with a velocity 80 ms^{-1} (when on a flood relief mission), the distance at which the packet falls from the point of release is nearly
(a) 1500 m (b) $800\sqrt{2}$ m
(c) 1000 m (d) none of these.

6. A block of mass 2 kg is placed on the floor. The coefficient of static friction is 0.4. If a force of 2.8 N is applied on the block parallel to floor, the force of friction between the block and floor (Take g = 10 m/s^2) is
(a) 2.8 N (b) 8 N (c) 2 N (d) zero.

7. Two bodies are projected at angles θ and $(90°-\theta)$ with the horizontal at the same speed. The ratio of their maximum heights is
(a) 1 : 1 (b) 1 : $\tan\theta$
(c) $\tan\theta$: 1 (d) $\tan^2\theta$: 1.

8. A wooden block of mass 0.9 kg is suspended from the ceiling of a room by thin wires. A bullet of mass 0.1 kg moving horizontally with a speed of 100 ms^{-1} strikes the block and sticks to it. What is the height to which the block rises? (Take g = 10 ms^{-2}).
(a) 2.5 m (b) 5.0 m
(c) 7.5 m (d) 10.0 m.

9. Two bodies with masses M_1 and M_2 have equal kinetic energies. If P_1 and P_2 are their respective momenta, then P_1/P_2 is equal to
(a) $M_1 : M_2$ (b) $M_1^2 : M_2^2$
(c) $M_2 : M_1$ (d) $\sqrt{M_1} : \sqrt{M_2}$.

10. A bomb of mass 30 kg at rest explodes into two pieces of masses 18 kg and 12 kg. The velocity of 18 kg mass is 6 ms^{-1}. The kinetic energy of the other mass is
(a) 324 J (b) 486 J
(c) 256 J (d) 524 J.

11. A book of mass 0.5 kg has its length 75 cm and breadth 25 cm. Then the moment of inertia about an axis perpendicular to the book and passing through the centre of gravity of the book is
(a) $\frac{10}{289}$ kg m^2 (b) $\frac{282}{10}$ kg m^2
(c) $\frac{10}{384}$ kg m^2 (d) $\frac{10}{483}$ kg m^2.

12. A round disc of moment of inertia I_2 about its axis perpendicular to its plane and passing through its centre is placed over another disc of moment of inertia I_1 rotating with an angular velocity ω about the same axis. The final angular velocity of the combination of disc is
(a) ω (b) $\frac{I_1\omega}{I_1 + I_2}$
(c) $\frac{(I_1 + I_2)\omega}{I_1}$ (d) $\frac{I_2\omega}{I_1 + I_2}$.

13. g_e and g_p denote the acceleration due to gravity

on the surface of the earth and another planet whose mass and radius are twice to that of the earth, then

(a) $g_p = \frac{g_e}{2}$ (b) $g_p = g_e$

(c) $g_p = 2g_e$ (d) $g_p = \frac{g_e}{\sqrt{2}}$.

14. A body of mass 2 kg is floating in water with half its volume submerged. What would be the force required to wholly submerge it into water ?

(a) 2 N (b) 9.8 N

(c) 19.6 N (d) 4.9 N.

15. When two soap bubbles of radii r_1 and r_2 ($r_2 > r_1$) coalesce, the radius of curvature of common surface is

(a) $r_2 - r_1$ (b) $\frac{r_2 - r_1}{r_1 r_2}$

(c) $\frac{r_1 r_2}{r_2 - r_1}$ (d) $r_2 + r_1$

16. An object entering the Earth's atmosphere at a high velocity catches fire due to

(a) viscosity of air

(b) the higher heat content of the atmosphere

(c) the pressure of certain larger gases

(d) the higher force of gravity.

17. A polyatomic gas with n degree of freedom has a mean energy per molecule is given by

(a) $\frac{nKT}{N}$ (b) $\frac{nKT}{2N}$

(c) $\frac{nKT}{2}$ (d) $\frac{3KT}{2}$.

18. One mole of an ideal gas ($C_P / C_V = \gamma$) at absolute temperature T_1 is adiabatically compressed from an initial pressure P_1 to a final pressure P_2. The resulting temperature T_2 of the gas is given by

(a) $T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{\gamma}{\gamma-1}}$ (b) $T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$

(c) $T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\gamma}$ (d) $T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\gamma-1}$

19. The original temperature of a blackbody is 727°C. The temperature to which this black body must be raised so as to double the total radiant energy is

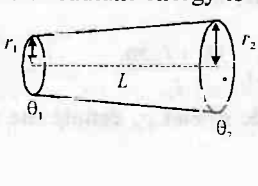
(a) 1454 K

(b) 2000 K

(c) 1190 K

(d) 917 K.

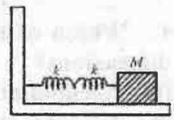
20. The rate of heat flow through a cross-section of the rod shown below is ($\theta_2 > \theta_1$ and thermal conductivity of the material of the rod is K.)



(a) $\frac{K\pi r_1 r_2(\theta_2 - \theta_1)}{L}$ (b) $\frac{K\pi(r_1 + r_2)^2(\theta_2 - \theta_1)}{4L}$

(c) $\frac{K\pi(r_2 + r_1)^2(\theta_2 - \theta_1)}{L}$ (d) $\frac{K\pi(r_2 + r_1)^2(\theta_2 - \theta_1)}{2L}$.

21. A mass m is suspended from the two coupled springs connected in series. The force constant for springs are k_1 and k_2. The time period of the suspended mass will be



(a) $T = 2\pi\sqrt{\frac{m}{k_1 - k_2}}$ (b) $T = 2\pi\sqrt{\frac{mk_1k_2}{k_1 + k_2}}$

(c) $T = 2\pi\sqrt{\frac{m}{k_1 + k_2}}$ (d) $T = 2\pi\sqrt{\frac{m(k_1 + k_2)}{k_1k_2}}$.

22. Two springs are connected to a block of mass M placed on a frictionless surface as shown below. If both the springs have a spring constant k, the frequency of oscillation of the block is

(a) $\frac{1}{2\pi}\sqrt{\frac{k}{M}}$ (b) $\frac{1}{2\pi}\sqrt{\frac{k}{2M}}$

(c) $\frac{1}{2\pi}\sqrt{\frac{2k}{M}}$ (d) $\frac{1}{2\pi}\sqrt{\frac{M}{k}}$

23. The equation of a plane progressive wave is given by $y = 5\cos\pi\left(200t - \frac{x}{150}\right)$ where x and y are in cm and t is in second. The velocity of the wave is

(a) 2 m/s (b) 200 m/s

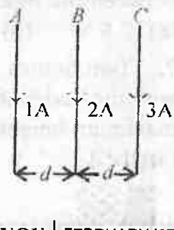
(c) 300 m/s (d) 150 m/s.

24. Two vibrating strings of the same material but lengths L and $2L$ have radii $2r$ and r, respectively. They are stretched under the same tension. Both the strings vibrate in their fundamental modes, the one of length L with frequency υ_1 and the other with frequency υ_2. The ratio υ_1/υ_2 is given by

(a) 2 (b) 4

(c) 8 (d) 1.

25. Three long straight wires A, B and C are carrying currents as shown in figure. Then the resultant force on B is directed



(a) perpendicular to the plane of paper and outward

(b) perpendicular to the plane of paper and inward
(c) towards A (d) towards C.

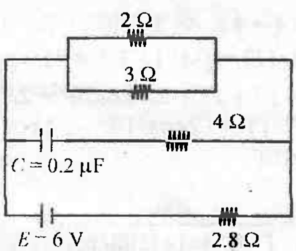
26. 27 identical drops of water are falling down vertically in air each with a terminal velocity $0.15\ ms^{-1}$. If they combine to form a single bigger drop what will be its terminal velocity?
(a) $0.3\ ms^{-1}$ (b) $1.35\ ms^{-1}$
(c) $0.45\ ms^{-1}$ (d) $0\ ms^{-1}$.

27. A given charge is situated at a certain distance from an electric dipole in the end on position, experiences a force F. If the distance of the charge is doubled, the force acting on the charge will be
(a) $F/8$ (b) $F/4$
(c) $F/2$ (d) $2F$.

28. A parallel plate capacitor of capacitance C is charged using a battery of emf V_0. After the capacitor is charged, the battery is removed and the distance between the capacitors is doubled. Find the new energy stored.
(a) $\frac{CV_0^2}{2}$ (b) $\frac{CV_0^2}{4}$
(c) CV_0^2 (d) $2CV_0^2$.

29. Electric charges +10 μC, + 5 μC, –3 μC and +8 μC are placed at the corners of a square of side $\sqrt{2}$ m. The potential at the centre of the square (V) is
(a) 1.8×10^6 V (b) 1.8 V
(c) 1.8×10^5 V (d) 18×10^5 V.

30. In the circuit shown, the internal resistance of the cell is negligible. The steady state current in the 2 Ω resistor is



(a) 0.6 A (b) 0.9 A
(c) 1.2 A (d) 1.5 A.

31. Resistance of a coil is 4.2 Ω at 100°C and the temperature coefficient of resistance of its material is 0.004/°C. Then its resistance at 0°C is
(a) 5 Ω (b) 3 Ω
(c) 4 Ω (d) 3.5 Ω.

32. For a given temperature difference which of the following pairs will generate maximum thermo e.m.f.?
(a) Lead-nickel (b) Copper-iron
(c) Gold-silver (d) Antimony-bismuth.

33. One junction of a certain thermocouple is at a fixed temperature T_r and the other junction is at a temperature T. The electromotive force for this is expressed by, $E = k(T - T_r)\left[T_0 - \frac{1}{2}(T + T_r)\right]$.
At, temperature $T = T_0/2$, the thermo electric power is
(a) $kT_0/2$ (b) kT_0
(c) $\frac{kT_0^2}{2}$ (d) $\frac{kT_0}{4}$.

34. Three bulbs of ratings 40W, 60W and 100W are designed to work on 220V mains. Which bulb will burn most brightly if they are connected in series-across 220V mains?
(a) 40W bulb
(b) 60W bulb (c) 100W bulb
(d) All bulbs will burn equally brightly.

35. Two straight long conductors AOB and COD are perpendicular to each other and carry curents I_1 and I_2 respectively. The magnitude of the magnetic induction at a point P at a distance r from the point O in a direction perpendicular to the plane $ABCD$ is
(a) $\frac{\mu_0(I_1 + I_2)}{2\pi r}$ (b) $\frac{\mu_0(I_1 - I_2)}{2\pi r}$
(c) $\frac{\mu_0}{2\pi r}\left[\frac{I_1 I_2}{I_1 + I_2}\right]$ (d) $\frac{\mu_0}{2\pi r}\left(I_1^2 + I_2^2\right)^{1/2}$

36. For a paramagnetic material, the dependence of the magnetic susceptibility χ on the absolute temperature T is given by
(a) $\chi \propto T$ (b) $\chi \propto$ constant × T
(c) $\chi \propto \frac{1}{T}$ (d) χ = constant.

37. The turn ratio of a transformer is 5 and the impedance of primary coil is 100 Ω. What is the impedance of the secondary coil?
(a) 500 Ω (b) 1000 Ω
(c) 2500 Ω (d) 10000 Ω.

38. In an electromagnetic wave the energy density associated with the electric field will be
(a) $\frac{1}{2}\varepsilon_0 E^2$ (b) $\frac{1}{2}CV^2$
(c) $\frac{1}{2}\frac{\varepsilon^2}{E}$ (d) $\frac{1}{2}\frac{q^2}{C}$.

39. Distance of distinct vision is 25 cm. The focal length of the convex lens is 5 cm. It can act as a

magnifier of magnifying power

(a) 6 (b) less than 5

(c) 5 (d) more than 6.

40. If a thin prism of glass is dipped into water then minimum deviation (with respect to air) of light produced by prism will be

$\left({}^a\mu_g = \frac{3}{2} \text{ and } {}^a\mu_w = \frac{4}{3}\right)$

(a) $\frac{1}{2}$ (b) $\frac{1}{4}$ (c) 2 (d) $\frac{1}{5}$.

41. White light is incident on a soap film of thickness 5×10^{-5} cm and refractive index 1.33. Which wavelength is reflected maximum in the visible region?

(a) 26600 Å (b) 8866 Å

(c) 5320 Å (d) 3800 Å.

42. The graph between the frequency of incident light and the stopping potential is a

(a) parabola (b) straight line

(c) hyperbola (d) circle.

43. In hydrogen spectrum, the shortest wavelength in Balmer series is λ. The shortest wavelength in Brackett series will be

(a) 2λ (b) 4λ (c) 9λ (d) 16λ.

44. The half-life of radium is 1600 years. The fraction of a sample of radium that would remain after 6400 years

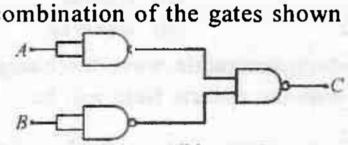
(a) $\frac{2}{4}$ (b) $\frac{1}{2}$ (c) $\frac{1}{8}$ (d) $\frac{1}{16}$.

45. The wavelength of the K_α line for an element of atomic number 43 is λ. Then the wavelength of the K_α line for an element of atomic number 29, is

(a) $\left(\frac{43}{29}\right)\lambda$ (b) $\left(\frac{42}{28}\right)\lambda$

(c) $\left(\frac{9}{4}\right)\lambda$ (d) $\left(\frac{4}{9}\right)\lambda$.

46. The combination of the gates shown in the fig.



(a) OR gate (b) AND gate

(c) NOR gate (d) XOR gate.

47. The current gain of a transistor is 100. The transistor is connected in common emitter configuration. What would be the change in emitter current when collector current changes by 1 mA?

(a) 1.1 mA (b) 1.01 mA

(c) 0.01 mA (d) 10 mA.

48. The width of depletion region in a *pn* junction diode

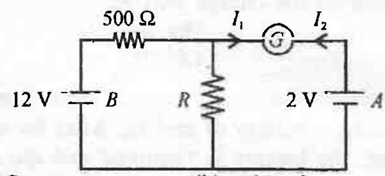
(a) increases when a reverse bias is applied

(b) increases when a forward bias is applied

(c) decreases when a reverse bias is applied

(d) remains the same, irrespective of the bias voltage.

49. In the circuit, the galvanometer *G* shows zero deflection. If the batteries *A* and *B* have negligible internal resistance, the value of resistor *R* will be



(a) 500 Ω (b) 1000 Ω

(c) 200 Ω (d) 100 Ω.

50. A comet moves in an elliptical orbit with an eccentricity of 0.20 around a star. The distance between the perihelion and the aphelion is 1.0×10^8 km. If the speed of the comet at perihelion is 81 km/s, then the speed of the comet at the aphelion is

(a) 182 km/s (b) 36 km/s

(c) 121.5 km/s (d) 54 km/s.

SOLUTIONS

1. (d) : Dipole moment $p - qa$

So, its dimensions $[\bar{p}] = [M^0 L T^1 A^1]$

Electric flux $\phi = \oint \vec{E}.d\vec{S}$ So, $[\phi] = [M^1 L^3 T^{-3} A^{-1}]$

Electric field $[E] = [M^1 L^1 T^{-3} A^{-1}]$.

2. (c) : $R^2 = F^2 + F^2 + 2F^2\cos 20° = 2F^2(1 + \cos 20°)$

or $R^2 = 2F^2(1 + 2\cos^2 10° - 1) = 4F^2\cos^2 10°$

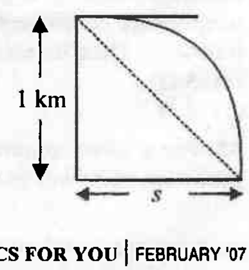
or $R = 2F\cos 10°$.

3. (b) : $48 = \frac{200}{(100/40) + (100/v)}$

or $\frac{1}{40} + \frac{1}{v} - \frac{2}{48} = \frac{1}{24}$

or $\frac{1}{v} = \frac{1}{24} - \frac{1}{40} = \frac{2}{120} = \frac{1}{60}$

4. (d)



5. (b) : $\frac{1}{2}gt^2 = 1000$

$\therefore$ $t^2 = 1000/5$

$t = 10\sqrt{2}$ s

$s = v_H \times t$, where v_H is the horizontal component of velocity

$s = 80 \times t = 800\sqrt{2}$ m.

6. (a) : Minimum force required to move the block $= \mu R = \mu mg = 0.4 \times 2 \times 10 = 8$ N.

Since the force applied is only 2.8 N, the block fails to move. $\therefore$ static friction = applied force = 2.8 N.

7. (d) : $h_{max.} = \dfrac{v^2 \sin^2\theta}{2g}$

$h'_{max.} = \dfrac{v^2\sin^2(90°-\theta)}{2g}$ or $h'_{max.} = \dfrac{v^2\cos^2\theta}{2g}$

Dividing, $\dfrac{h_{max.}}{h'_{max.}} = \dfrac{\sin^2\theta}{\cos^2\theta} = \dfrac{\tan^2\theta}{1}$.

8. (b) : Mass of block $(M) = 0.9$ kg, mass of bullet $(m) = 0.1$kg, initial velocity of bullet $(u_1) = 100\ \text{ms}^{-1}$ and initial velocity of block $(u_2) = 0$.

$\therefore$ Momentum of bullet and block before impact $= mu_1 + Mu_2 = mu_1$.

Let v be the velocity of the bullet + block after impact. Then, the momentum after impact $= (m + M)v$.

From the principle of conservation of momentum, we have

$mu_1 = (m + M)v$

or $v = \dfrac{mu_1}{(M+m)} = \dfrac{0.1\times 100}{(0.9+0.1)} = 10\ \text{ms}^{-1}$

Kinetic energy of (bullet + block) $= \dfrac{1}{2}(m+M)v^2$ ...(i)

Let the bullet + block system rise to a height h. At this height, potential energy of (bullet + block) $= (m + M)gh$ ....(ii)

Equating (i) and (ii), we get $h = \dfrac{v^2}{2g} = \dfrac{(10)^2}{2\times 10} = 5$ m.

9. (d) : Given that :

$\dfrac{1}{2}M_1v_1^2 = \dfrac{1}{2}M_2v_2^2$ or $\dfrac{v_1}{v_2} = \sqrt{\dfrac{M_2}{M_1}}$

$\therefore \dfrac{P_1}{P_2} = \dfrac{M_1v_1}{M_2v_2} = \dfrac{M_1}{M_2}\sqrt{\dfrac{M_2}{M_1}} = \sqrt{\dfrac{M_1}{M_2}}$.

10. (b) : According to law of conservation of momentum

$30 \times 0 = 18 \times 6 + 12 \times v \quad \therefore \quad v = -9$ m/s

Negative sign indicated that both fragments move in opposite directions.

Kinetic energy of 12 kg mass $= \dfrac{1}{2}mv^2$

$= \dfrac{1}{2}\times 12\times 81 = 486$ J.

11. (c) : Moment of inertia of a rectangular block about an axis through its centre of gravity

$I = \dfrac{M}{12}\left[l^2 + b^2\right]$

$I = \dfrac{0.5}{12}\left[\left(\dfrac{3}{4}\right)^2 + \left(\dfrac{1}{4}\right)^2\right] = \dfrac{10}{384}$ kg m^2.

12. (b) : From conservation of angular momentum, we have

L = constant $\Rightarrow I\omega$ = constant $\Rightarrow I\omega = I'\omega'$

Substituting $I = I_1$, $I' = (I_1+I_2)$ which is total moment of inertia of combination we get : $\omega' = \dfrac{I_1}{I_1+I_2}\omega$.

13. (a) : $g = \dfrac{GM}{R^2}$

For earth, $g_e = \dfrac{GM_e}{R_e^2}$

For other planet, $g_p = \dfrac{GM_p}{R_p^2}$

$\dfrac{g_e}{g_p} = \left(\dfrac{M_e}{M_p}\right)\left(\dfrac{R_p}{R_e}\right)^2 = \left(\dfrac{1}{2}\right)\left(\dfrac{2}{1}\right)^2 = 2$

$\dfrac{g_e}{g_p} = 2$, $g_p = \dfrac{g_e}{2}$.

14. (c) : Up thrust $= \dfrac{V}{2}\times 1000\,g$ Newton

In equilibrium position $2g = \dfrac{V}{2}\times 1000g$

$\therefore V = \dfrac{4}{1000}$ m^3

$\therefore$ Force required to wholly submerge the body into water

$= \dfrac{V}{2}\times d\times g = \dfrac{4\times 1000\times 9.8}{1000\times 2} = 19.6$ N.

15. (c) : $\dfrac{4S}{R} = \dfrac{4S}{r_1} - \dfrac{4S}{r_2}$

where S is the surface tension

or $\dfrac{1}{R} = \dfrac{1}{r_1} - \dfrac{1}{r_2}$ or $R = \dfrac{r_1r_2}{r_2 - r_1}$

16. (a) : Energy is dissipated in overcoming viscous force.

17. (c) : Mean K.E/molecule $= \frac{n}{2}KT$

18. (b) : For an adiabatic process, PV^γ = constant. The ideal gas equation for one mole of a gas is $PV = RT$ or $V = RT/P$. Therefore, we have

$$P\left(\frac{RT}{P}\right)^\gamma = \text{constant}$$

or $\frac{T^\gamma}{P^{\gamma-1}}$ = constant ($\because R$ is a constant)

$$\therefore \frac{T_2^\gamma}{P_2^{\gamma-1}} = \frac{T_1^\gamma}{P_1^{\gamma-1}} \quad \text{or} \quad T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$$

19. (c) : From Stefan's law, the total radiant energy is given by

$Q = eA\sigma T^4 t$

$$\frac{Q_2}{Q_1} = \frac{T_2^4}{T_1^4} = \left(\frac{T_2}{T_1}\right)^4, \text{ But } \frac{Q_2}{Q_1} = 2$$

$T_1 = 727 + 273 = 1000$ K

$$2 = \left(\frac{T_2}{1000}\right)^4 \Rightarrow 2^{\frac{1}{4}} = \frac{T_2}{1000}$$

$T_2 = (1000)(2)^{1/4} = (1000)(1.19) = 1190$ K.

20. (a) : $r_{\text{eff}} = \sqrt{r_1 r_2}$

$$\frac{dQ}{dt} = \frac{KA(\theta_2 - \theta_1)}{L} = \frac{K\pi r_1 r_2(\theta_2 - \theta_1)}{L}$$

21. (d) : The effective spring constant of two springs in series is $k = \frac{k_1 k_2}{k_1 + k_2}$

Time period,

$$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{m(k_1+k_2)}{k_1 k_2}}.$$

22. (b) : The frequency of oscillation of a vibrating spring is given by $\upsilon = \frac{1}{2\pi}\sqrt{\frac{k}{M}}$ ....(i)

Since, the springs are attached in series, each having spring constant k, so we have:

$$\frac{1}{k_{eff}} = \frac{1}{k} + \frac{1}{k} = \frac{2}{k}$$

$$\Rightarrow k_{eff} = \frac{k}{2}$$

Hence, using relation (i), we have

$$\upsilon = \frac{1}{2\pi}\sqrt{\frac{k_{eff}}{M}} = \frac{1}{2\pi}\sqrt{\frac{k}{2M}}.$$

23. (c) : The given equation is $y = 5\cos\left(200\pi t - \frac{\pi x}{150}\right)$

Compare with $y = a\cos\left(\frac{2\pi t}{T} - \frac{2\pi x}{\lambda}\right)$

$a = 5$ cm, $\frac{2\pi t}{T} = 200\pi t \quad \therefore T = \frac{1}{100} = 0.01$ s

$$\upsilon = \frac{1}{T} = \frac{1}{0.01} = 100 \text{ Hz}$$

$$\frac{2\pi x}{\lambda} = \frac{\pi x}{150}$$

$\lambda = 300$ cm $= 3$ m

$v = \upsilon\lambda = 100 \times 3 = 300$ m/s.

24. (d) : Frequency of the fundamental mode is given by

$\upsilon = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$; T = tension and μ = mass per unit length

$$\therefore \frac{\upsilon_1}{\upsilon_2} = \frac{(1/2L)\sqrt{T/\mu_1}}{(1/4L)\sqrt{T/\mu_2}} = 2\sqrt{\frac{\mu_2}{\mu_1}}$$

$$\text{Now } \mu_1 = \frac{M_1}{L} = \frac{\pi(2r)^2 L\rho}{L} = 4\pi r^2\rho$$

$$\text{and } \mu_2 = \frac{M_2}{2L} = \frac{\pi(r)^2(2L)\rho}{2L} = \pi r^2\rho$$

$$\text{Hence } \frac{\upsilon_1}{\upsilon_2} = 2 \times \sqrt{\frac{\pi r^2\rho}{4\pi r^2\rho}} = 1.$$

25. (d) : Force per unit length between two infinitely long parallel current carrying conductors is given by $F = \frac{\mu_0}{4\pi}\left(\frac{2I_1 I_2}{r}\right)$

Using this relation, force between A and B is given by $F_{AB} = \frac{\mu_0}{4\pi}\frac{2\times1\times2}{d} = \frac{\mu_0}{4\pi}\frac{4}{d}$ ......(i)

Similarly, $F_{CB} = \frac{\mu_0}{4\pi}\frac{2\times2\times3}{d} = \frac{\mu_0}{4\pi}\frac{12}{d}$ ......(ii)

Clearly, from (i) and (ii), we have $F_{CB} > F_{AB}$

Hence, resultant force on B is directed towards C.

26. (b) : Let r = radius of small drop

$\therefore R = n^{1/3}r = 3r$

Stoke's law gives, $6\pi r\eta v = \frac{4}{3}\pi r^3 g(\rho - \sigma)$ *i.e.*, $v \propto r^2$

$$\frac{v_1}{r^2} = \frac{v_2}{R^2} = \frac{v_2}{9r^2} \quad \therefore v_2 = 9 \times v_1$$

$v_1 = 0.15$ m/s $\quad \therefore v_2 = 0.15 \times 9 = 1.35$ m/s.

27. (a) : $E \propto \frac{1}{x^3}$ due to a dipole.

28. (c) : Charge remains conserved

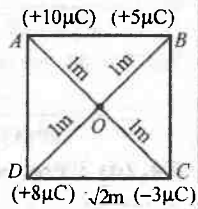
$\therefore Q = CV_0 = C'V'$ As $C' = C/2$

$\therefore V' = 2V_0$

New energy stored

$\frac{1}{2}C'V'^2 = \frac{1}{2}\frac{C}{2}(2V_0)^2 = CV_0^2.$

29. (c) : Diagonal $BD = 2$ m (using Pythagoras theorem)



Hence, $OD = OC = OB = OA = 1$m

Potential at the centre of the square due to the charges placed at the four corners is given by

$$(V)_{at\,O} = k\left[\frac{q_1}{r_1} + \frac{q_2}{r_2} + \frac{q_3}{r_3} + \frac{q_4}{r_4}\right]$$

where $k = \frac{1}{4\pi\varepsilon_0}$

On putting the values of

$k = 9\times10^9\,\text{Nm}^2\text{C}^{-2}$

$q_1 = +10\times10^{-6}$ C; $q_2 = +5\times10^{-6}$ C; $q_3 = -3\times10^{-6}$ C; $q_4 = +8\times10^{-6}$ C; and $r_1 = r_2 = r_3 = r_4 = 1$m, the value of potential at O comes out to be $(V)_{at\,O} = 1.8 \times 10^5$ V.

30. (b) : Given : Capacitance of the capacitor (C) = 0.2 μF and e.m.f. of cell $(E) = 6$ V.

Reactance of a capacitor for a cell, which is a DC source, is infinity. Therefore no current flows in 4 Ω resistance. Resistances 2 Ω and 3 Ω (both in upper arm) are connected in parallel.

Therefore, their equivalent resistance

$$(R') = \frac{2\times3}{2+3} = 1.2\,\Omega.$$

Now, R' and 2.8 Ω are in series combination. Therefore, equivalent resistance of the circuit.

$$R = R' + 2.8 = 1.2 + 2.8 = 4\,\Omega$$

Current drawn in the circuit, $I = \frac{E}{R} = \frac{6}{4} = 1.5$ A

Therefore, potential difference across 2 Ω resistance, $V = IR' = 1.5 \times 1.2 = 1.8$ V

Thus, current in 2 Ω resistance

$$(I_1) = \frac{V}{2} = \frac{1.8}{2} = 0.9\text{ A.}$$

31. (b) : $R_t = R_0(1 + \alpha t)$

or $R_0 = \frac{R_t}{1+\alpha t} = \frac{4.2}{1+0.004\times100} = 3\,\Omega.$

32. (d) : Seeback arranged the metals in a series. Bi, Ni, Co, Pt, Cu, Mn, Pb, Au, Ag, Zn, Cd, Fe, Sb. The farther the metals are in the series, the greater will be thermo-emf produced in the circuit for a given difference of temperature between the junctions.

33. (a) : $E = k\left[TT_0 - \frac{T^2}{2} - \frac{TT_r}{2} - T_rT_0 + \frac{TT_r}{2} + \frac{T_r^2}{2}\right]$

Hence, Thermoelectric power is

$$\frac{dE}{dT} = k\left[T_0 - T - \frac{T_r}{2} + \frac{T_r}{2}\right] = k(T_0 - T)$$

At temperature $T = T_0/2$,

thermoelectric power = $k(T_0 - T_0/2) = kT_0/2$.

34. (a) : Wattage = voltage × current, *i.e.* $W = VI$. But $I = V/R$. Therefore $W = V^2/R$, or $R = V^2/W$.

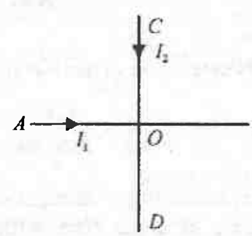
$\therefore$ Resistance of 40W bulb $= \frac{220\times220}{40} = 1210\,\Omega$

Resistance of 60W bulb $= \frac{220\times220}{60} = 807\,\Omega$

Resistance of 100W bulb $= \frac{220\times220}{100} = 484\,\Omega$

Since the bulbs are connected in series, the same current I flows through each. The brightness depends on I^2R. Since the 40W bulbs has the highest resistance, it will give the maximum glow.

35. (d) : The magnetic field induction at a point P at a perpendicular distance r from O in a direction perpendicular to the plane $ABCD$ due to currents through AOB and COD are perpendicular to each other.



Hence, $B = (B_1^2 + B_2^2)^{1/2}$

$$= \left[\left(\frac{\mu_0}{4\pi}\frac{2I_1}{r}\right)^2 + \left(\frac{\mu_0}{4\pi}\frac{2I_2}{r}\right)^2\right]^{1/2} = \frac{\mu_0}{2\pi r}\left(I_1^2 + I_2^2\right)^{1/2}$$

36. (c) : According to Curie's law, $\chi = \frac{C\mu_0}{T}$

where C is Curie's constant.

37. (c) : n = Turn ratio

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s} = \sqrt{\frac{Z_s}{Z_p}} \Rightarrow \frac{Z_s}{Z_p} = n^2.$$

38. (a) : The energy per unit volume in a electric field is given by $u_E = \frac{1}{2}\varepsilon_0 E^2$.

39. (a) : $M = 1 + \frac{D}{f} = 1 + \frac{25}{5} = 6.$

40. (b) : $\delta = (\mu - 1)A$

For glass $\mu = 1.5$

Hence $\delta_1 = (1.5 - 1)A = 0.5\,A$

For glass prism in water $\ {}^{w}\mu_g = \frac{{}^{a}\mu_g}{{}^{a}\mu_w} = \frac{3/2}{4/3} = \frac{9}{8}$

Hence $\delta_2 = \left(\frac{9}{8} - 1\right)A = \frac{1}{8}A \quad \therefore \frac{\delta_2}{\delta_1} = \frac{\frac{1}{8}A}{0.5A} = \frac{1}{4}$

41. (c) : In reflected light, condition for maximum intensity is $2\mu t\cos r = (2n+1)\frac{\lambda}{2} \quad \therefore \lambda = \frac{4\mu t\cos r}{2n+1}$

$$\lambda = \frac{4 \times 1.33 \times 5 \times 10^{-7} \times 1}{(2n+1)}$$

Putting n = 0, 1, 2, 3,....we get

$\lambda_0 = 26600$Å, $\lambda_1 = 8866$Å

$\lambda_2 = 5320$Å, $\lambda_4 = 3800$Å

Among these wavelengths, $\lambda = 5320$Å is in the visible region.

42. (b) : According to Einstein's photoelectric equation

$$h\upsilon - h\upsilon_0 = \left(\frac{1}{2}mv^2\right)_{\max.}$$

But $\left(\frac{1}{2}mv^2\right)_{\max.} = eV_s$

$\therefore \quad eV_s = h\upsilon - h\upsilon_0$ or $V_s = \frac{h}{e}\upsilon - \frac{h}{e}\upsilon_0$

Representing υ along x-axis and V_s along y-axis, we get a straight line with slope (h/e) and intercept $(-h\upsilon_0/e)$.

43. (b) : $\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

For shortest wavelength in Balmer series,

$n_1 = 2$; $n_2 = \infty$

$\frac{1}{\lambda} = R\left[\frac{1}{4} - \frac{1}{\infty}\right]$ or $\lambda = \frac{4}{R}$

For shortest wavelength in Brackett series is

$\frac{1}{\lambda'} = R\left[\frac{1}{4^2} - \frac{1}{\infty^2}\right] \quad \therefore \lambda' = \frac{16}{R} = 4 \times \frac{4}{R} = 4\lambda.$

44. (d) : $\frac{N}{N_0} = \left(\frac{1}{2}\right)^n$ where $n = \frac{t}{T_{1/2}}$

Given $T_{1/2}$ = 1600 years and t = 6400 years

$n = \frac{t}{T_{1/2}} = \frac{6400}{1600} = 4 \qquad \frac{N}{N_0} = \left(\frac{1}{2}\right)^4 = \frac{1}{16}.$

45. (c) : From Moseley's law, $\sqrt{\upsilon} = a(Z - b)$

For K_α line, $b = 1$, $\sqrt{\upsilon} = a(Z-1)$

Squaring, we get : $\upsilon = a^2(Z-1)^2$ or $\frac{c}{\lambda} = a^2(Z-1)^2$

or $\lambda = \frac{c}{a^2(Z-1)^2}$

For Z = 43, wavelength = λ

$$\therefore \lambda = \frac{c}{a^2(43-1)^2} \quad .....\text{(i)}$$

For Z = 29, wavelength = λ'

$$\lambda' = \frac{c}{a^2(29-1)^2} \quad ....\text{(ii)}$$

Dividing eq. (ii) by eq. (i), we get

$$\frac{\lambda'}{\lambda} = \frac{(43-1)^2}{(29-1)^2} = \left(\frac{42}{28}\right)^2 = \left(\frac{3}{2}\right)^2 \quad \therefore \lambda' = \left(\frac{9}{4}\right)\lambda.$$

46. (a) : The Boolean expression of this gate is

$Y = \overline{\overline{A}\cdot\overline{B}} = \overline{\overline{A+B}} = A + B$

Thus OR gate is produced.

47. (b) : $\beta_{ac} = \frac{\Delta I_c}{\Delta I_b} = \frac{\Delta I_c}{\Delta I_e - \Delta I_c}$ or $100 = \frac{1}{\Delta I_e - 1}$

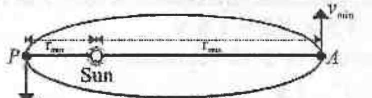
$\Delta I_e - 1 = \frac{1}{100} = 0.01$ or $\Delta I_e = 1 + 0.01 = 1.01$ mA.

48. (a) : The width of depletion region in pn junction diode increases when reverse bias is applied whereas decreases when forward bias is applied.

49. (d) : Galvanometer will show zero deflection, if $I_1 = I_2$

$\therefore \frac{12}{500+R} = \frac{2}{R}$ or $R = 100\ \Omega.$

50. (d) : P represents perihelion position and A represents aphelion position. Then



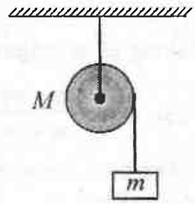
$\frac{v_{max}}{v_{min}} = \frac{r_{max}}{r_{min}} = \frac{1+e}{1-e}$

$\therefore \frac{81}{v_{min}} = \frac{1+0.2}{1-0.2} = \frac{1.2}{0.8} = \frac{3}{2}$ or $v_{min} = \frac{2}{3} \times 81 = 54$ km/s.

Thought Provoking Problems in ROTATIONAL MOTION

By : Er. Sudhir Singh *

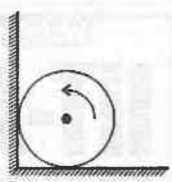
1. A light thread with a body of mass m tied at its end and is wound on a uniform solid cylinder of mass M and radius R as shown in figure. At a moment $t = 0$, the system is set in motion. Assuming the friction in the axle of the cylinder to be negligible. Find the time dependence of



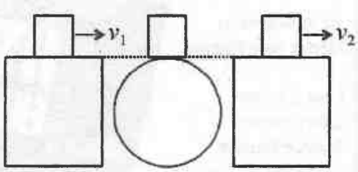
(i) the angular velocity of the cylinder

(ii) the kinetic energy of the whole system.

2. A uniform cylinder of radius R is spinning about its axis with the angular velocity ω_0 and then placed into a corner as shown in figure. The coefficient of friction between the corner walls and the cylinder is equal to μ. How many turns will the cylinder accomplish before it stops?



3. The axis of the cylinder given in the figure is fixed. The cylinder is initially at rest. The block of mass m is initially moving to the right without friction and with speed v_1. If passes over the cylinder to the dashed position. When it first makes the contact with the cylinder, it slips on the cylinder but the friction is large enough so that slipping ceases before m looses contact with the cylinder. The cylinder has a radius R and a rotational inertia I. Find final speed v_2.



4. Find out centre of mass of a thin semicircular wire of radius R.

5. A disc of radius R is cut out from a larger disc of radius $2R$ in such a way that the edge of the hole touches the edge of the disk. Locate the centre of mass of the residual disk.

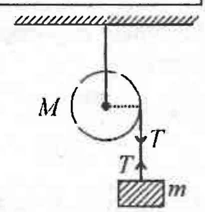
6. Two physics teachers one of 50 kg and other of 60 kg are sitting at two extreme of 4 m long boat (40 kg) standing still in water. They discuss a rotational problem and come to mid of the boat. Neglect friction of water how far does the boat move on the water during the process?

SOLUTIONS

1. $mg - T = ma$ (i)

$TR = I\alpha$

$$= \frac{MR^2}{2} \cdot \frac{a}{R} \qquad \text{(ii)}$$



from (i) and (ii)

$$a = \frac{2mg}{M + 2m} \quad \therefore \quad \alpha = \frac{a}{R} = \frac{2mg}{R(M + 2m)}$$

$$\therefore \quad \omega = \omega_0 + \alpha t$$

$$\omega = 0 + \frac{2mg\,t}{2(M + 2m)} = \frac{2mgt}{2(M + 2m)}$$

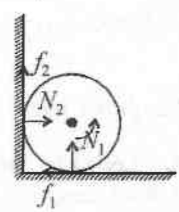
$$\text{Total K.E.} = \frac{1}{2} I\omega^2 + \frac{1}{2}mv^2 = \frac{mg^2t^2}{2\left(1 + \frac{M}{2m}\right)}$$

2. $\sum F_x = 0$

$\therefore f_1 = N_2$ ...(i)

$\sum F_y = 0$

$mg - N_1 + f_2$ ...(ii)



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$f_1 = \mu N_1; f_2 = \mu N_2$

$\therefore$ from above we have

$$f_1 = \frac{\mu mg}{1+\mu^2} \text{ and } f_2 = \frac{\mu^2 mg}{1+\mu^2}$$

Retarding torque is provided by the frictional force.

$-(f_1 + f_2)R = I\alpha$

$$\therefore \alpha = -\frac{2\mu g}{R}\,\frac{(1+\mu)}{(1+\mu^2)}$$

$$\omega^2 = \omega_0^2 + 2\alpha\theta$$

$$0 = \omega_0^2 - 2\times\frac{2\mu g\,(1+\mu)\theta}{R\,(1+\mu^2)}$$

$$\theta = \frac{\omega_0^2 R(1+\mu^2)}{4\mu g(1+\mu)}$$

$$\theta = 2\pi n \quad \Rightarrow n = \frac{\theta}{2\pi} = \frac{\omega_0^2 R\,(1+\mu^2)}{8\pi\,\mu g\,(1+\mu)}$$

3. From impulse momentum

$m(v_1 - v_2) = F\Delta T$ .....(i)

$I\omega = F\Delta tR$ .....(ii)

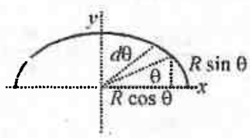
From (i) and (ii)

$$\therefore mv_1 = mv_2 + \frac{I\omega}{R} \quad .....(iii)$$

According to problem $v_2 = R\omega \Rightarrow \omega = v_2/R$ from (iii)

$$\therefore v_2 = \frac{mv_1}{m + \frac{I}{R^2}}$$

4. Since it is symmetrical about y-axis that is why x_{CM} will be at origin. Let M is mass of the given wire. Considering a small element. Its mass



$$dm = \frac{M}{\pi R}(Rd\theta) = \frac{M}{\pi}d\theta$$

$$y_{CM} = \frac{1}{M}\int y\,dm = \frac{1}{M}\int_0^{\pi} R\sin\theta\,\frac{M}{\pi}\,d\theta = \frac{2R}{\pi}$$

Similarly $x_{CM} = \frac{1}{M}\int x\,dm = \frac{1}{M}\int_0^{\pi} R\cos\theta\,\frac{M}{\pi}\,d\theta = 0$

Centre of mass $\rightarrow \left(0, \frac{2R}{\pi}\right)$

5. Let O be the origin

T thickness, and ρ density

mass of cutout disk $m_1 = \pi R^2 T\rho$

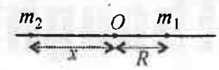
its position of centre of mass $x_1 = R$

mass of the whole disk $M = \pi(2R)^2 T\rho$

$\therefore m_2 = M - m_1 = 3\pi R^2 T\rho$

For the whole, the centre of mass is at O

$$x_{CM} = \frac{m_2 x + m_1 R}{m_1 + m_2} \text{ w.r.t. } O$$



$$\therefore x = \frac{m_1 R}{m_2} = \frac{\pi R^2 T\rho\cdot R}{3\pi R^2 T\rho} = \frac{R}{3} \text{ to the left of } O.$$

6. $m_1 = 60$ kg,

$m_2 = 40$ kg; $m_3 = 50$ kg

$x_1 = 0, x_2 = 2$ m, $x_3 = 4$ m

Taking O as origin

$$x_{CM} = \frac{-m_1x_1 + m_2x_2 + m_3x_3}{m_1 + m_2 + m_3} = 1.87 \text{ meter}$$

When both come at the centre centre of mass will be at 2 m from O.

$\therefore$ Boat shift $= 2 - 1.87$

$= 0.13$ m

Boat has to move because position of centre of mass does no change as no force is acting. ❖

Thought Provoking Problems in GRAVITATION

By : Er. Sudhir Singh *

1. Find the gravitational potential energy of a particle of mass m and a thin uniform rod of mass M and length L, if they are situated at a distance l apart (from the end). Find the force of interaction between them.

2. An artificial satellite of moon revolves in a circular orbit whose radius is n times the radius of the moon. Assuming that the satellite experiences a resistive force due to cosmic dust that depends upon the velocity v of the satellite as $F = kv^2$, where k is a constant.

Find how long the satellite will stay in the orbit until it falls on the moon's surface.

3. Two neutron stars each of mass 0.74×10^{29} kg and radius 11.25 km are separated by a centre to centre distance of 90 km. They are initially at rest with respect to each other.

(i) How fast are they moving when their separation has decreased to one half of its initial value?

(ii) How fast they are moving just before they collide? (ignore relativistic effect).

4. A hypothetical planet of mass M has three moon each of the equal mass m, each revolving in same circular orbit of radius R. The mass are equally spaced and thus form an equilateral triangle. Find
(i) The total potential energy of the system.
(ii) The orbital speed of each moon such that they maintain this configuration.

5. A planet A moves along elliptical orbit around the sun. At the moment when it was at the distance r from the sun its velocity was equal to v_0 and angle between the radius vector r_0 and the velocity vector v_0 was equal to α. Find maximum and minimum distance that will separate this planet from the sun during its orbital motion.

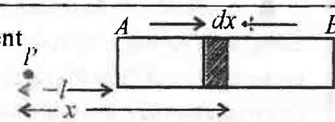
6. A spherical hollow is made in a lead sphere of radius r, such that its surface touches the outside surface of the lead sphere and passed through its centre. The mass of the sphere before hollowing was M. With what force will hollow lead sphere attract a small sphere of mass m, which lies at a distance d from the centre of lead sphere on the straight line connecting the centres of the spheres and of the hollow.

7. A tunnel is dug through the earth along one of its diameters. Show that the body dropped in this tunnel executes SHM about the centre of the earth. Assume the earth is a sphere of uniform density.

8. A uniform ring of mass m and radius r is placed directly above a uniform sphere of mass M and of equal radius. The centre of the ring is at a distance $\sqrt{3}r$ from the centre of sphere. What will be gravitational force exerted by the sphere on the ring?

SOLUTIONS

1. Mass of element



$$dm = \frac{M}{L}dx$$

Potential Energy. $dU = -\frac{Gm\,dm}{x}$

$$dU = -\frac{GmM}{L}\frac{dx}{x}$$

$$\therefore \int dU = -\int_l^{L+l} \frac{GMm\,dx}{Lx} \Rightarrow U = -\frac{GMm}{L}\log_e\left(1+\frac{L}{l}\right)$$

Force $F = \int dF = \frac{GMm}{L}\int_l^{L+l}\frac{dx}{x^2}$

$$F = \frac{GMm}{l(L+l)}$$

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2. Let R is the radius of moon. Orbital velocity of satellite in an orbit of radius $R = \sqrt{\frac{GM}{R}}$.
Orbital velocity of satellite in an orbit of radius nR

$$= \sqrt{\frac{GM}{nR}}$$

where M is mass of the moon.

$F = kv^2$ or $m\frac{dv}{dt} = kv^2$

$$\int_0^t dt = \frac{m}{k}\int_{\sqrt{GM/nR}}^{\sqrt{GM/R}} \frac{dv}{v^2} \qquad \therefore t = \frac{m}{k}\left[\sqrt{\frac{nR}{GM}} - \sqrt{\frac{R}{GM}}\right]$$

3. (i) Using energy conservation
Loss in potential energy = Gain in kinetic energy

$$-\frac{Gm_1m_2}{d} - \left(-\frac{Gm_1m_2}{d/2}\right) = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

since $m_1 = m_2 = m$; and $v_1 = v_2 = v$

$$\therefore v = \sqrt{\frac{GM}{d}} = 7.41\times10^6 \text{ m/sec.}$$

(ii) Again using the same concept

$$-\frac{Gm_1m_2}{d} - \left(-\frac{Gm_1m_2}{r_1+r_2}\right) = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

$m_1 = m_2 = m$; and $v_1 = v_2 = v$

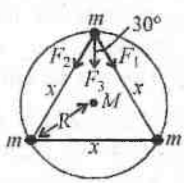
$$\therefore v_2 = Gm\left[\frac{1}{r_1+r_2} - \frac{1}{d}\right] \Rightarrow v = 1.28\times10^7 \text{ m/sec}$$

4. $x = \sqrt{3}\,R$

(i) Potential energy $\Rightarrow$ it will be due mutual interaction between each moon as well as with planet.

$$\therefore \text{Potential energy} = 3\left[-\frac{GMm}{R} - \frac{Gmm}{x}\right]$$

$$\therefore \text{Potential Energy} = -3\frac{Gm}{R}\left[M + \frac{m}{\sqrt{3}}\right]$$



(ii) $F_1 = F_2 = \frac{Gmm}{x^2}$

$$F_3 = \frac{GMm}{R^2}$$

Resultant of F_1, F_2 & F_3 ; $F = \frac{Gm}{R^2}\left(M + \frac{m}{\sqrt{3}}\right)$

It will provide necessary centripetal force

$$\frac{mv^2}{R} = \frac{Gm}{R^2}\left(M + \frac{m}{\sqrt{3}}\right) \qquad v = \sqrt{\frac{GM}{R} + \frac{Gm}{\sqrt{3}R}}$$

5. From law of conservation of momentum

$mv_0r_0 \sin\alpha = m_1v_1r = mv_2r$ ......(i)

From conservation of energy

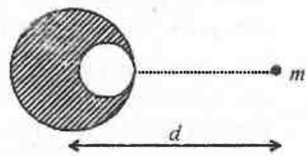
$$\frac{1}{2}mv_0^2 + \left(-\frac{GM_sm}{r_0}\right) = \frac{1}{2}mv_1^2 + \left(-\frac{GM_sm}{r_1}\right) \quad ......(ii)$$

From (i) and (ii)

$$r_1 = \frac{1 \pm \sqrt{1 - v_0^2 r_0^2 \sin\alpha\left(\frac{2}{r_0} - \frac{v_0^2}{GM_s}\right)}}{\frac{2}{r_0} - \frac{v_0^2}{GM_s}}$$

6. Mass of the sphere which is taken out

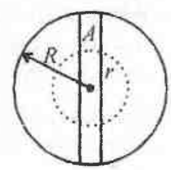
$$= \frac{M}{\frac{4}{3}\pi R^3}\,\frac{4}{3}\pi\left(\frac{R}{2}\right)^3 = \frac{M}{8}$$



Force of attraction
= Due to bigger sphere – due to smaller (cut) sphere.

$$= \frac{GMm}{d^2} - \frac{G\frac{M}{8}m}{\left(d-\frac{R}{2}\right)^2} = GMm\left(\frac{1}{d^2} - \frac{1}{8\left(d-\frac{R}{2}\right)^2}\right)$$

7. Let the body is at A



$$\therefore \text{Force} = F = \frac{Gm\left[\frac{M}{\frac{4}{3}\pi R^3}\times\frac{4}{3}\pi r^3\right]}{r^2}$$

$$F = -\frac{GMm}{R^3}r$$

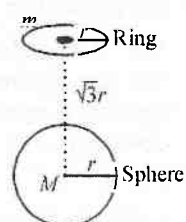
Since $F \propto r$ and negative it will execute SHM.

$F = -kr$

$\therefore \frac{GMm}{R^3}r = kr$, k is force constant. $k = \frac{GMm}{R^3}$

Time period $T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{R}{g}} = 84.6$ minute.

8. Gravitationmal field intensity due to ring is given by



$$I = \frac{Gm\sqrt{3}r}{\left[r^2 + (\sqrt{3}r)^2\right]^{\frac{3}{2}}} = \frac{\sqrt{3}\,Gm}{8r^2}$$

$\therefore$ Force $F = M \times I$

$$= \frac{\sqrt{3}\,GMm}{8r^2}$$

PRACTICE PAPER FOR IIT-JEE 2007

Exam on 8th April

PAPER - I

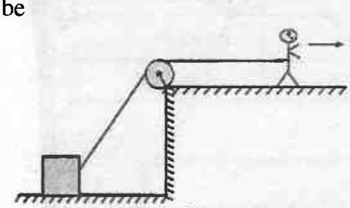
PHYSICS

Section - I (Q. No. 1 to 12)
(Only one option is correct)

1. A planet is rotating around the sun with angular speed ω_1. It is rotating about it's own axis with an angular speed ω_2. It is given that axes of two rotations mentioned above are parallel. The relation between ω_1 and ω_2 so that there will always be day on one half of the planet and always night on the other half is

(a) ω_1 can have any value and $\omega_2 = 0$
(b) $\omega_1 = \omega_2$
(c) $\omega_1 = 2\omega_2$
(d) $\omega_1 = \omega_2/2$.

2. A boy is pulling a block of mass 20 kg on a smooth horizontal floor as shown in figure. The boy is applying a constant force of 100 N on the rope. If the block starts from rest, its speed after the boy has moved a distance of 10 m will be

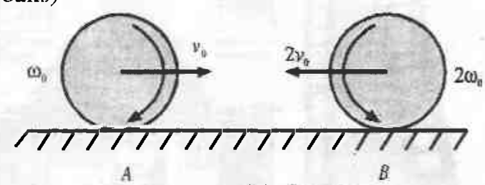


(a) 5 m/s (b) 10 m/s
(c) 20 m/s (d) data insufficient.

3. A force $\vec{F} = 5z\hat{i} + xy\hat{j} + x^2z\hat{k}$

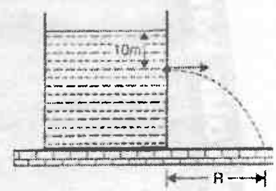
(a) is conservative
(b) is non-conservative
(c) is conservative along some paths
(d) may be conservative or non conservative depending upon x, y, z.

4. Two identical balls are rolling without slipping on a horizontal plane as shown in figure. They undergo a perfectly elastic collision. Just after the collision the speeds of bottom points of balls A and B will be respectively (Assume that there is no friction between the balls)



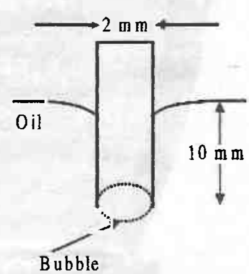
(a) zero, zero (b) $2v_0$, $4v_0$
(c) $3v_0$, $3v_0$ (d) none of these.

5. A large tank is filled with water (density=10^3 kg/m^3). A small hole is made at a depth 10 m below water surface. The range of water issuing out of the hole is R on ground. What extra pressure must be applied on the water surface so that the range becomes $2R$ (take 1 atm = 10^5 Pa and g = 10 m/s^2)



(a) 9 atm (b) 4 atm
(c) 5 atm (d) 3 atm

6. A glass tube of 2 mm internal diameter is immersed in an oil of mass density 960 kg/m^3 to a depth of 10 mm. If a minimum pressure of 172 N/m^2 is needed to form a bubble of radius 1mm, the surface tension of the oil is approximately (Neglect atmospheric pressure)



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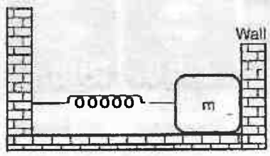
(a) 0.02 N/m (b) 0.04 N/m
(c) 0.06 N/m (d) 0.08 N/m

7. In the figure, the block of mass m, attached to the spring of stiffness is in contact with the completely elastic wall, and the compression in the spring is e. The spring is compressed further by e by displacing the block towards left and is then released. If the collision between the block and the wall is completely elastic then the time period of oscillations of the block will be



(a) $\frac{2\pi}{3}\sqrt{\frac{m}{k}}$

(b) $2\pi\sqrt{\frac{m}{k}}$

(c) $\frac{\pi}{3}\sqrt{\frac{m}{k}}$ (d) $\frac{\pi}{6}\sqrt{\frac{m}{k}}$.

8. The excess pressure in a travelling sound wave is given by

$$\Delta P = \frac{P_A}{200\sqrt{3}} \sin\left[\frac{2\pi}{\lambda}\left(x - 1000\frac{t}{3}\right)\right]$$

where P_A is the atmospheric pressure. If $\lambda = 1$m then the net pressure at a point $x = 34$ m, and $t = 0.1$s is given by

(a) $\frac{399}{400}P_A$ (b) $\frac{401}{400}P_A$

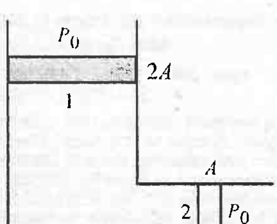
(c) $\frac{P_A}{200\sqrt{3}}$ (d) none of these.

9. An ideal gas has adiabatic exponent γ. In some process its molar heat capacity varies as $C - \alpha/T$, where α is a constant. Work performed by one mole of gas during its heating from T_0 to nT_0 will be

(a) $\alpha \log n$ (b) $\alpha \log n - (n-1)RT_0$

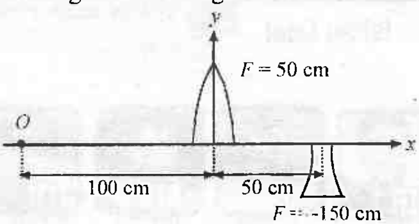
(c) $\alpha \log n - \frac{(n-1)}{(\gamma-1)}RT_0$ (d) none of these.

10. n moles of an ideal monoatomic gas are enclosed betweentwo diathermic, light smooth pistons as shown in figure. If piston - 1 is compressed by a distance x, piston - 2 moves out by a distance y where,



(a) $y = x$ (b) $y = 2x$
(c) $y > 2x$ (d) $y < 2x$

11. A converging half lens and a diverging half lens are arranged coaxially as shown in figure. O is a point object placed on the common optic axis and x - y axes are taken as shown in figure. The images of O are formed at



(a) (100, 0), (–25, 0)
(b) (100, 0), (–75, 0)
(c) (100, 0), (–25, 0), (–50, 0)
(d) none of these.

12. A diwali light series consists of n identical bulbs connected in series. The whole series is being powered by a 220V ideal DC battery. If resistance of one of the bulbs is doubled the brightness of that bulb and net light output by the total series will respectively

(a) decrease, decrease (b) increase, increase
(c) decrease, increase (d) increase, decrease

Section - II
(More than one option may be correct)
(Q. No. 13 to 20)

13. An initially uncharged capacitor C is connected in series with resistor R. This combination is then connected to a battery of emf V_0. Sufficient time elapses so that a steady state is reached. Which of the following statements is not true?

(a) The time constant is independent of V_0
(b) The final charge on C is independent of R
(c) The total energy dissipated by R is independent of R
(d) The total energy dissipated by R is independent of V_0

14. The internal energy of a system remains constant when it undergoes

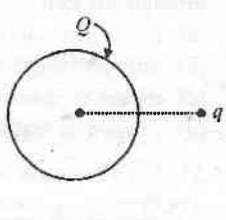
(a) a cyclic process
(b) an isothermal process
(c) an adiabatic process
(d) any process in which the heat given out by the system equals the work done on the system

15. When temperature is increased
(a) viscosity of gases increases
(b) viscosity of gases decreases
(c) viscosity of liquids decreases
(d) viscosity of liquids increases

16. A circular metal plate is heated by placing its centre vertically over a candle flame. Then, if the plate does not bend then,
(a) a compressive stress is developed in the plate
(b) a tensile stress is developed in the plate
(c) no stress is developed in the plate
(d) distance between any two points on the disk increases in same ratio

17. Choose the correct statement/s
(a) For an isotropic body, coefficient of thermal expansion is same along all directions
(b) Fractional change in distance between two points on heating is directly proportional to the α along a line joining them
(c) Work done by a non-conservative force must be negative
(d) Temperature of an iron cube of mass 1 kg will be dependent on the frame of reference of observer

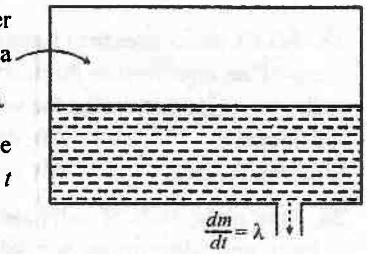
18. A point charge is placed in front of a conducting solid sphere of radius R at a distance d from its centre. The sphere is given a total charge Q. The total electrostatic energy of this system is



(a) $\frac{kQ^2}{2R}+\frac{kQq}{d}$
(b) less than $\frac{kQ^2}{2R}+\frac{kQq}{d}$
(c) greater than $\frac{kQ^2}{2R}+\frac{kQq}{d}$
(d) insufficient data

19. An electric dipole $\vec{p}=p_0(\hat{i}+\hat{j}+\hat{k})$ is kept at origin. Then, the electric field vector at a point $A(1, 2, 3)$ will be (Assuming SI units for all given data)
(a) zero
(b) $\frac{kp}{98\sqrt{14}}(2\hat{i}+11\hat{j}+20\hat{k})$
(c) $\frac{kp}{49\sqrt{14}}(2\hat{i}+17\hat{j}+28\hat{k})$
(d) none of these.

20. A well insulated box contains water (specific heat = c) of mass m_0 and temperature T_0 at time $t = 0$. If heat is being added to it uniformly at a constant rate $dQ/dt = R$ and water is leaking from it at a constant rate $\frac{dm}{dt}=\lambda$ then the temperature of the liquid at time t $\left(t<\frac{m_0}{\lambda}\right)$ will be



(a) $T=\frac{R}{2\lambda}\ln\left(\frac{m_0}{m_0-\lambda t}\right)+T_0$
(b) $T=\frac{R}{\lambda}\ln\left(\frac{m_0}{m_0-\lambda t}\right)+T_0$
(c) $T=\frac{R\lambda}{c}e^{(m_0-\lambda t)}$
(d) none of these.

CHEMISTRY

Section - I

(Only one option is correct) (Q. No. 21 to 32)

21. Which of the following combinations of quantum numbers do not represent permissible solutions of the Schrodinger wave equation for the hydrogen atom?

	n	l	m	s
(i)	3	0	1	$-\frac{1}{2}$
(ii)	2	2	0	$+\frac{1}{2}$
(iii)	4	3	–4	$-\frac{1}{2}$
(iv)	5	2	2	$+\frac{1}{2}$
(v)	3	2	–2	$-\frac{3}{2}$

(a) (iii)
(b) (iv) and (v)
(c) (ii), (iv), and (v)
(d) (i), (ii), (iii), and (v)

22. $POCl_3$ contains P–O bond that involves ______ overlap between orbitals of O and P atoms respectively
(a) $p\pi-p\pi$
(b) $p\pi-d\pi$
(c) $d\pi-p\pi$
(d) $\sigma(p-d)$

23. m grams of a mixture of Na_2CO_3 and $NaHCO_3$ yields one mole of CO_2 on treatment with HCl. After this reaction the solution is evaporated and yields 1.4 mole of NaCl. What is the value of m?
(a) 95 gm
(b) 101 gm
(c) 97.2 gm
(d) 92.4 gm

24. From your knowledge of mechanisms in organic chemistry, it is to be expected that carbon atom in carbonyl group is normally most susceptible to attack by
(a) electrophiles
(b) nucleophiles
(c) acids
(d) free radicals

25. SO_2Cl_2 dissociates in SO_2 and Cl_2. The average molar mass of an equilibrium mixture of these three gases will________ on increasing the volume of the container.

(a) increase (b) decrease
(c) remain same (d) oscillate

26. One mole each of sulphates of sodium, barium, copper and aluminium are added to 1L of water separately. Their boiling points are observed to be T_1, T_2, T_3 and T_4 respectively then

(a) $T_2 < T_3 < T_4 < T_1$ (b) $T_2 = T_3 < T_1 < T_4$
(c) $T_2 < T_3 < T_1 < T_4$ (d) $T_3 < T_4 < T_2 = T_1$

27. Identify the correct statement from the given informations.

	Rate constant	Temp.	Frequency Factor
(i) $A \rightarrow B$ 1st order	K_1	T	A
(ii) $X \rightarrow Y$ 1st order	$K_2 (K_1 > K_2)$	T	A

(a) Reaction (i) is endothermic but reaction (ii) is exothermic
(b) $\Delta H_{(i)} > \Delta H_{(ii)}$
(c) $E_{a(i)} < E_{a(ii)}$
(d) $\Delta S_1 > \Delta S_2$

28. Which of the following is never found in native state in nature?

(a) Gold (b) Zinc
(c) Copper (d) Mercury

29. Which of the following will sublime on heating ?

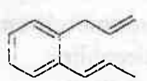
(a) $AlCl_3$ (b) $AlCl_3 \cdot 6H_2O$
(c) BN (d) borax

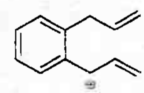
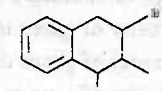
30. Na_2SnS_3 contains ionizable

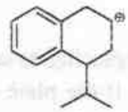
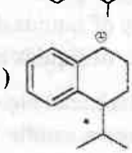
(a) Na^+ ions (b) Sn^{2+} ions
(c) Sn^{4+} ions (d) S_3^{2-} ions

31. If n carbon–carbon bonds are present in C_nH_m such that exactly equal energy is required to break all the carbon–carbon bonds, then which of the following may be true ?

(a) $m = 2n + 2$ (b) $m = 2n$
(c) $m = 2n - 2$
(d) no relation between m and n may be concluded from this information

32.  on addition of $\overset{\oplus}{C}H_3$ finally produces which of the following as major product?

(a)  (b) 

(c)  (d) 

Section - II
(More than one option may be correct)
(Q. No. 33 to 40)

33. Aqueous solutions of which of the following salts, when electrolysed using inert electrodes, will raise the pH of the solution?

(a) NaCl (b) K_2SO_4
(c) $CuSO_4$ (d) $BaCl_2$

34. Which of the following function as weak acids in water capable of decolorising permanganic acid?

(a) HOBr (b) H_3PO_4
(c) H_3PO_3 (d) HI

35. Iodine – oxygen bond is stronger in first member of which of the following pairs?

(a) IO_3^-, HIO_3 (b) IO^-, IO_3^-
(c) IO_6^{5-}, IO_4^- (d) IO_4^-, IO^-

36. A solution containing Na^+, NO_3^-, Cl^- and SO_4^{2-} ions, all at unit concentrations, is electrolyzed between nickel anode and platinum cathode. As the current is passed through the cell

(a) pH of the solution increases
(b) only hydrogen is liberated at cathode
(c) nickel is deposited at cathode
(d) oxygen is major product at anode

37. For the consecutive reaction $A \xrightarrow{k_1(\text{time}^{-1})} B \xrightarrow{k_2(\text{time}^{-1})} C$, following curves were obtained depending upon the relative values of k_1 and k_2. Which of the following is the correct match ?

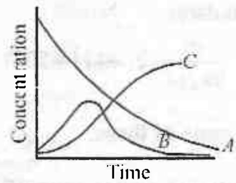


Figure 1

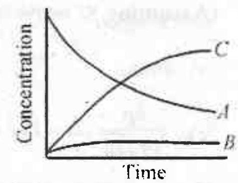
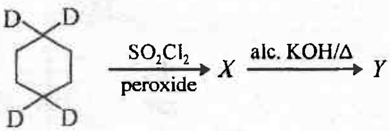


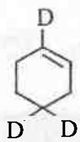
Figure 2

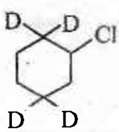
(a) figure 1($k_1 < k_2$) (b) figure 2($k_1 < k_2$)
(c) figure 1($k_1 >> k_2$) (d) figure 2($k_1 >> k_2$)

38. Let the colour of the indicator HIn(colourless) will be visible only when its ionised form (pink) is 25% or more in a solution. Suppose HIn ($pK_a = 9.0$) is added to a solution of pH = 9.6, predict what will happen ? (Take log 2 = 0.3)
(a) Pink colour will not be visible
(b) Pink colour will be visible
(c) % of ionised form will be less than 25%
(d) % of ionised form will be more than 25%

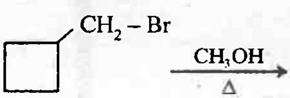
39. Which observation/s will be correct about the major products X and Y of the following reaction ?

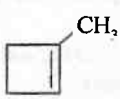


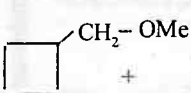
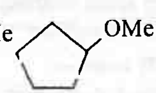
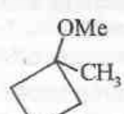
(a) X is  (b) Y is 

(c) X is  (d) Y is 

40. In the given reaction following products are expected.



 + 
(I) (II)

+  +  + 
(III) (IV) (V)

Which observation seem to be correct ?
(a) Formation of II or V involves a strained carbocation intermediate
(b) IV is the major product obtained by S_N1 reaction
(c) I[st] is the major product obtained by E1 reaction
(d) In the solvolysis reactions a carbocation intermediate is formed

MATHEMATICS

Section - I
(Only one option is correct) (Q. No. 41 to 52)

41. If the polynomial $f(x) = ax^3 + bx^2 + cx + d$ has extrema at $x = \alpha$ and $x = 2\alpha$ then
(a) a, b, c are in A.P
(b) a, b, c are in G.P.
(c) $6a, 4b, 9c$ are in A.P.
(d) $6a, 4b, 9c$ are in G.P.

42. Let ABC be an equilateral triangle whose orthocentre is the origin O. If $\overline{OA} = \bar{a}, \overline{OB} = \bar{b}$ then $\overline{OC}$ is
(a) $\bar{a} + \bar{b}$ (b) $\dfrac{\bar{a}+\bar{b}}{2}$
(c) $-(\bar{a} + \bar{b})$ (d) $-2(\bar{a} + \bar{b})$

43. If a vertex, the circumcentre and the centroid of a triangle be (0, 0), (3, 4) and (6, 8) respectively then the triangle must be
(a) right triangle (b) equilateral
(c) isosceles (d) right isosceles

44. Let $A = \{1, 2, ...50\}$ and $B = \{2, 4, 6, ...100\}$ the number of elements $(x, y) \in A \times B$ such that $x + y = 50$ is
(a) 24 (b) 25
(c) 50 (d) 75

45. The area of the region in the argand plane in which z can belong, satisfying the inequalities $1 \le |z - 1| \le 4$ and $z + \bar{z} > 2$ is
(a) 15π (b) $15/2\pi$
(c) π (d) none of these.

46. The value of $\tan^{-1}\left(\dfrac{\sin 2 - 1}{\cos 2}\right)$ is equal to
(a) $\dfrac{\pi}{2} - 1$ (b) $2 - \dfrac{\pi}{2}$
(c) $1 - \dfrac{\pi}{4}$ (d) $\dfrac{\pi}{4} - 1$

47. If $f(a + x) = f(2a)$ for all $x \in R$ and a is positive constant then $f(x)$ is
(a) a periodic function of the period a
(b) a periodic function of indeterminate period
(c) a non periodic function
(d) a montonic function

48. C_1, C_2, C_3.....is a sequence of circles such that C_{n+1} is the director circle of C_n. If the radius of C_1 is a, the area bounded by the circles C_n and C_{n+1} is

(a) $\pi \cdot 2^n a^2$ (b) $\pi \cdot 2^{2n-2} \cdot a^2$
(c) $\pi \cdot 2^{n-1} \cdot a^2$ (d) none of these

49. The graph of the curve
$x^2 + y^2 - 2xy - 8x - 8y + 32 = 0$ falls wholly in the
(a) I Quadrant (b) II Quadrant
(c) III Quadrant (d) none of these.

50. Let $f(x)$ be a function which can be expressed as a power series such that
$f(0) = pf'(0) = pq\,f''(0) = pq^2 \ldots\ldots\ldots f^n(0) = pq^n$ where
$f^n(0) = \left[\dfrac{d^n f(x)}{dx^n}\right]_{x=0}$ then $\lim_{x \to \infty} f(x)$ is
(a) p (b) q
(c) $p \cdot e^{pq}$ (d) $q \cdot e^{pq}$

51. If α, β be unequal real roots of the equation $ax^2 + bx + c = 0$ where a, b, c are real and y is the solution of $2ax + b = 0$ then
(a) $\gamma > \alpha, y > \beta$ (b) $\gamma < \alpha, \gamma < \beta$
(c) $\alpha < \gamma < \beta$ or $\beta < \gamma < x$ (d) none of these.

52. The angle between the straight lines joining the point $(-1,0)$ to the common points of $3x - 2y + 2 = 0$ and $3x^2 + 5xy - 3y^2 + 8x + 8y + 5 = 0$
(a) $\pi/2$ (b) $\pi/4$
(c) $\pi/3$ (d) none of these.

Section - II
(More than one option may be correct)
(Q. No. 53 to 60)

53. Which of the following functions are odd functions?
(a) $f(x) = \dfrac{x}{e^{|x|} + \cos x}$
(b) $f(x) = x^2 \ln\left(\sqrt{x^6 + 1} + x^3\right)$
(c) $f(x) = \left(\dfrac{2^x - 1}{2^x + 1}\right)[g(x) + g(-x)]$
(d) $f(x) = \{g(x) + g(-x)\}\{h(x) + h(-x)\}$

54. The determinant
$\begin{vmatrix} \cos(\alpha+\beta) & \sin\alpha & -\cos\alpha \\ -\sin^2(\alpha+\beta) & \cos\alpha & -\sin\alpha \\ \cos 2\beta & \sin\beta & \cos\beta \end{vmatrix}$ is
(a) non-negative
(b) independent of α
(c) independent of β
(d) independent of α and β

55. If $\sum_{r=0}^{n} \dfrac{r}{{}^nC_r} = \sum_{r=0}^{n} \dfrac{n^2 - 3n + 3}{2\,{}^nC_r}$, then
(a) $n = 1$ (b) $n = 2$
(c) $n = 3$ (d) none of these.

56. If p^{th}, q^{th} and r^{th} of a H.P. with rational terms be a, b and c then the roots of the quadratic equation $ab(q-p)x^2 + bc(r-q)x + ca(p-r) = 0$ cannot be
(a) real (b) rational
(c) irrational (d) imaginary

57. In triangle ABC if $a + b + c = 2$, then
(a) $a + b + c + abc < 1$
(b) $a^2 + b^2 + c^2 + 2abc < 2$
(c) $ab + bc + ca \leq 4/3$
(d) $\dfrac{bc}{a} + \dfrac{ca}{b} + \dfrac{ab}{c} < 2$

58. Let PM be the perpendicular from the point $P(1, 2, 3)$ to x - y plane. If OP makes an angle θ with the positive direction of z-axis and OM makes an angle ϕ with the positive direction of x-axis where O is the origin and θ and ϕ are acute angles, then
(a) $\tan\theta = \dfrac{\sqrt{5}}{3}$
(b) $\sin\theta\sin\phi = \dfrac{2}{\sqrt{14}}$
(c) $\tan\phi = 2$
(d) $\cos\theta\cos\phi = \dfrac{1}{\sqrt{14}}$

59. The line $\dfrac{x-2}{3} = \dfrac{y-1}{2} = \dfrac{z-1}{-1}$ intersects the curve $x^2 - y^2 = a^2, z = 0$ if a is equal to
(a) 4 (b) 3
(c) -4 (d) none of these

60. Let $\vec{a}$ and $\vec{b}$ are two given perpendicular vectors, which are non-zero. A vector $\vec{r}$ satisfying the equation $\vec{r} \times \vec{b} = \vec{a}$, can be
(a) $\vec{b} - \dfrac{\vec{a} \times \vec{b}}{|\vec{b}|^2}$
(b) $2\vec{b} - \dfrac{\vec{a} \times \vec{b}}{|\vec{b}|^2}$
(c) $|\vec{a}|\vec{b} - \dfrac{\vec{a} \times \vec{b}}{|\vec{b}|^2}$
(d) $|\vec{b}|\vec{b} - \dfrac{\vec{a} \times \vec{b}}{|\vec{b}|^2}$

PAPER - II

PHYSICS

Section - 1

Comprehensive questions (Q. 1 to 10)

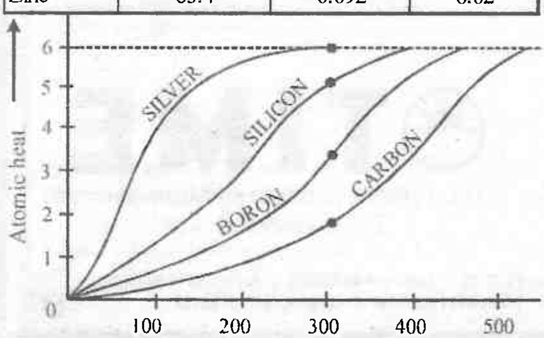
Comprehension - 1

Dulong and Petit's Law

Dulong and Petit, in 1819, studied the specific heat of various elements in a solid state and enunciated a law, called Dulong and Petit's law. **According to this law, the product of the specific heat and the atomic weight of all the elements in the solid state is a constant**. The value of this constant was fixed as 6.4 but it is taken as 6 at present. The exact value is 5.96 which also agrees with the value derived from the kinetic theory of matter.

This constant is generally called **atomic heat** of the element. Atomic heat of some common substances at 20°C has been given in the following table. It can be seen that apart from a few exceptions, the atomic heat of most of the substances is indeed nearly 6.0.

Atomic heat of substances at 20°C			
Substance	Atomic weight	Specific heat	Atomic heat
Aluminium	27.0	0.212	5.72
Boron	10.8	0.307	3.32
Carbon	12.0	0.160	1.92
Copper	63.6	0.091	5.79
Gold	197.2	0.031	6.11
Iron	55.8	0.110	6.12
Lead	207.2	0.030	6.21
Silicon	28.1	0.182	5.11
Silver	107.9	0.056	6.04
Zinc	65.4	0.092	6.02



It is found that Dulong and Petit's law is not true in the case of carbon, boron and silicon. In the case of these elements the atomic heats at 20°C are 1.92, 3.32 and 5.11. These values differ from the constant value of 6. This variation in atomic heat could not be explained on the basis of kinetic theory of matter. However, it was found by Nernst that the specific heat of substance decreases with decrease in temperature and at absolute zero the specific heat tends to be zero. Further, he was able to show that the specific heat increases with the rise in temperature and tends to a maximum value. Therefore, the atomic heat of substance tends to a maximum value of six and decreases with decrease in temperature. In the case of carbon, boron and silicon also, the atomic heat is 6 at high temperatures as shown in figure.

1. Atomic heat of which of the following substances is not expected to be near 6.0 at 20°C.

(a) Zinc (b) Calcium
(c) Steel (d) Uranium

2. Dulong and Petit's law is valid for

(a) only heavy elements (b) all solids
(c) all elements (d) all solid elements

3. According to Dulong and Petit's law it can be said that

(a) temperature of elements with higher atomic weights is more difficult to change
(b) temperature of elements with higher atomic weights is easier to change
(c) heavy elements tend to deviate from Dulong and Petit's law
(d) lighter elements tend to deviate from Dulong and Petit's law

4. Which of the following element deviates most strongly from Dulong and Petit's law ?

(a) Silver (b) Silicon
(c) Boron (d) Carbon

5. Using the experimental results of Nernst it can be said that, for a particular material, it is easier to increase the temperature at

(a) lower temperature (b) higher temperature
(c) 20°C (d) 100°C

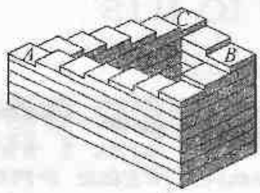
Comprehension - 2

Visualization exercise

You cannot always believe what you see. From the simplest drawings to complex photographs and artwork,

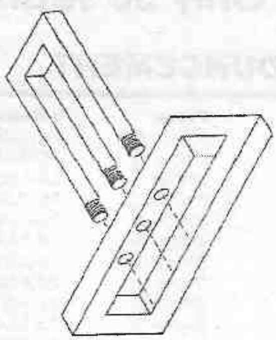
optical illusions have been around ever since paper and pencil were first used. Many 3 dimensional objects, when drawn on a paper are visualized differently by different people. The following questions test your ability to visualize 3-dimensional objects and interpret various details that they contain :

6. Looking at the figure shown here, which one of the following statements is the most appropriate ?



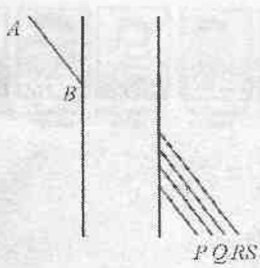
(a) Lowest point of the staircase is at A
(b) Highest point of the staircase is at B
(c) If you go from B to A, every step is lower than the previous one
(d) The staircase seems to constantly descend if you move your eyes around in clockwise direction

7. Choose the most appropriate statement regarding the given figure



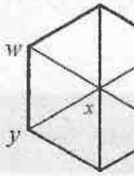
(a) The fork has three prongs
(b) If the fork is inserted in the rectangular ring, then it will touch one of the faces of the rectangular ring
(c) If the fork is inserted in the rectangular ring, then it will not touch one of the faces of the rectangular ring
(d) There is something wrong with the given figure

8. Which line on the right is collinear with the line on the left?



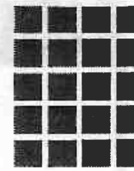
(a) P
(b) Q
(c) R
(d) S .

9. The figure shown here is



(a) a hexagon
(b) a cube
(c) either a hexagon or a cube
(d) a toroid

10. The figure shown here has



(a) only black and white colours
(b) black, white, grey colours
(c) no grey colour
(d) twenty black squares and twelve grey circles

Section - II

Match the following (Q. No. 11 to 14)

11. When photons of energy 4.25 eV strike the surface of a metal A, the ejected photoelectrons have maximum kinetic energy T_A eV and de Broglie wavelength λ_A. The maximum kinetic energy of photoelectrons liberated from another metal B by photons of energy 4.70 eV is $T_B = (T_A - 1.50)$ eV. If the de Broglie wavelength of these photoelectrons is $\lambda_B = 2\lambda_A$.

(a)	The work function of B	(P)	2.25 eV
(b)	The work function of A	(Q)	2.00 eV
(c)	T_A	(R)	4.20 eV

12. Four charges, all of the same magnitude, are placed at the four corners of a square. At the centre of the square, the potential is V and the field is E.

(a)	$V = 0$	(P)	$E = 0$
(b)	$V \neq 0$	(Q)	$V \neq 0$
(c)	$E = 0$	(R)	$E \neq 0$
(d)	$E \neq 0$	(S)	$V = 0$

13. A direct current of density $\vec{j}$ flows along a round uniform steel wire with cross-section radius R. Then the magnetic field vector of this current at a point whose position relative to the axis of the wire is defined by a radius vector $\vec{r}$.

(a)	$\frac{1}{2}\mu_0(\vec{j}\times\vec{r})$	(P)	for $r > R$
(b)	$\frac{1}{2}\mu_0(\vec{j}\times\vec{r})\frac{R^2}{r^2}$	(Q)	for $r < R$
(c)	zero	(R)	for $r = 0$

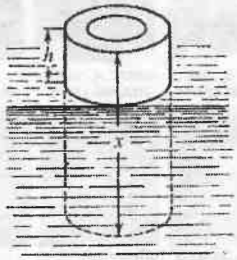
14. For a body executing simple harmonic motion with amplitude A, time period T, maximum velocity v_{max} and initial phase zero, which of the following matches best ?

(a)	At $y = A/2$	(P)	$y = A/2$
(b)	At $t - T/8$	(Q)	$y > A/2$
(c)	At $v = \frac{v_{max}}{2}$	(R)	$v > \frac{v_{max}}{2}$
(d)	At $t < T/8$		

Section - III

Subjective questions (Q. No. 15 to 18)

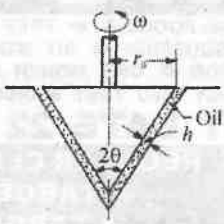
15. A tube floats vertically in water. The portion of the tube producing from the water is $h = 5$ cm. Oil with a specific weight of $\gamma = 0.9$ gf/cm^3 is poured into the tube. What length can the tube have so that it can be completely filled with oil?



16 The equation of two alternating e.m.f's are $e_1 = 150 \sin 377t$ volts and $e_2 = 150 \sin(377t + 60°)$ volts. What is the phase angle between the resultant and each of the two e.m.f's?

17. Two transverse sine waves, each of amplitude 4 mm, wavelength 2 m and time period 1 s and in phase at $x = 0$, $t = 0$ are travelling along the x-axis in opposite directions. Obtain the equation of the resultant wave and comment on its nature. Calculate the maximum displacement at $x = 2.3$ m. Also locate the nodes and antinodes.

18. A solid cone of radius r_0, and vertex angle 2θ is to rotate at an angular velocity ω. An oil of viscosity μ and thickness h fills the gap between the cone and the housing. Determine the torque T required to rotate the cone, at a constant angular speed.



CHEMISTRY

Section - 1

Comprehensive questions (Q. No. 19 to 30)

Comprehension - 1

The pH {-log [H$^+$]} value for pure water is 7.0, whereas natural rainwater is weakly acidic. This is caused by dissolution of atmospheric carbon dioxide. In many areas, however, rain water is more acidic. This has several causes, some of which are natural and some of which derive from human activity. In the atmosphere, sulphur dioxide and nitrogen monoxide are oxidised to sulphur trioxide and nitrogen dioxide respectively, which react with water to give sulphuric acid and nitric acid. The resulting so-called "acid rain" has an average pH of 4.5 value as low as 1.7 have however, been measured.

Sulphur dioxide SO_2, is diprotic acid in aqueous solution. At 27°C the acidity constants are

$$SO_{2(aq)} + H_2O_{(l)} \rightleftharpoons HSO^-_{3\,(aq)} + H^+_{(aq)}$$

$$K_{a_1} = \frac{[H^+][HSO_3^-]}{[SO_2]} = 10^{-2}\,M$$

$$HSO^-_{3\,(aq)} \rightleftharpoons SO^{2-}_{3\,(aq)} + H^+_{(aq)}$$

$$K_{a_2} = \frac{[SO_3^{2-}][H^+]^2}{[HSO_3^-]} = 10^{-7}\,M$$

and for equilibrium

$$SO_{2(aq)} + H_2O_{(l)} \rightleftharpoons SO^{2-}_{3\,(aq)} + 2H^+_{(aq)}$$

$$K = \frac{[SO_3^{2-}][H^+]^2}{[SO_2]} = K_{a_1} \times K_{a_2} = 10^{-9}\,M$$

Also for water $H_2O \rightleftharpoons H^+ + OH^-$

$K_w = [OH^-][H^+] = 10^{-14}$

($T = 300$ K for all questions).

19. The solubility of sulphur dioxide gas is 24.63 litre in 1 litre of water at partial pressure of 1 atm. Then the concentration of SO_2 in water saturated with SO_2 gas (the change in volume caused by dissolution of SO_2 may be ignored) ($R = 0.0821$ litre atm. mol^{-1}K^{-1}) is

(a) 1.2 M (b) 0.5 M
(c) 1 M (d) 2 M

20. The pH of 0.01 M aqueous solution of sodium sulphite will be

(a) 8.5 (b) 9
(c) 9.5 (d) 4.5

21. The dominant equilibrium in an aqueous solution of sodium hydrogen sulphite is

$$2HSO^-_{3\,(aq)} \rightleftharpoons SO_{2(aq)} + SO^{2-}_{3\,(aq)} + H_2O_{(l)}$$

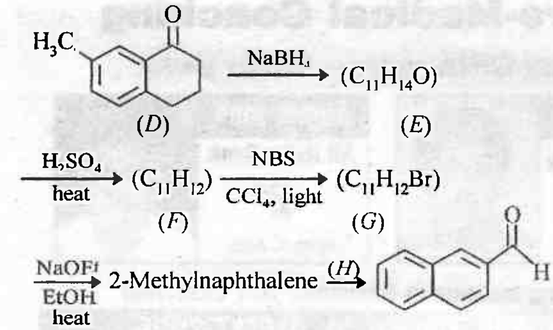
The equilibrium constant of the above reaction is

(a) 10^{-6} (b) 10^{-9}
(c) $10^{-3.5}$ (d) 10^{-5}

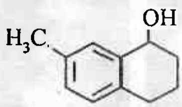
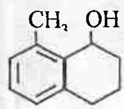
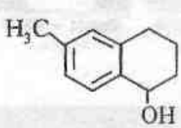
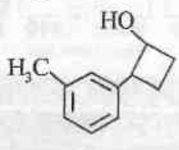
22. Bromine is added dropwise to a 0.01 M solution of SO_2. All sulphur dioxide is oxidised to sulphate (VI), excess of bromine is removed. Then which of the following balanced reactions represent the redox change:

(a) $2SO_{2(aq)} + Br_{2(aq)} \rightarrow 2SO^{2-}_{4\,(aq)} + 2Br^-_{(aq)} + 2H^+_{(aq)}$
(b) $H_2O_{(l)} + SO_{2(aq)} + Br_{2(aq)} \rightarrow SO^{2-}_{4\,(aq)} + 2Br^-_{(aq)} + 2H^+_{(aq)}$
(c) $SO_{2(aq)} + 2H_2O_{(l)} + Br_{2(aq)} \rightarrow SO^{2-}_{4\,(aq)} + 2Br^-_{(aq)} + 4H^+_{(aq)}$
(d) $2SO_{2(aq)} + 3Br_{2(aq)} + 4H_2O_{(l)} \rightarrow 2SO^{2-}_{4\,(aq)} + 6Br^-_{(aq)} + 8H^+_{(aq)}$

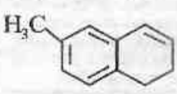
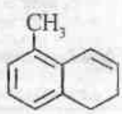
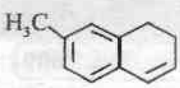
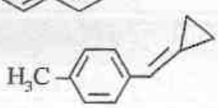
Comprehension - 2



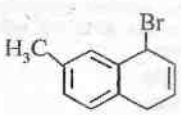
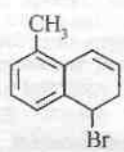
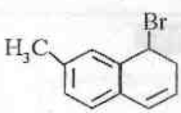
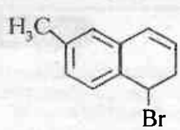
23. (*E*) is chiefly

(a) 
(b) 
(c) 
(d) 

24. (*F*) is chiefly

(a) 
(b) 
(c) 
(d) 

25. (*G*) is chiefly

(a) 
(b) 
(c) 
(d) 

26. Best choice for (*H*) is

(a) CrO_2Cl_2 (b) O_3/Me_2S
(c) hot acidified $KMnO_4$ (d) cold alkaline $KMnO_4$

Comprehension - 3

A solid (*A*) burns in a gas (*B*) to form a solid (*C*) and finally a liquid (*D*). When dissolved in water, both (*C*) and (*D*) give white precipitate with $AgNO_3$ as well as (*E*). The white precipitate with (*E*) dissolves on bubbling (*B*) through its suspension. (*E*) gives red precipitate with KI that dissolves in excess KI to give a colourless solution. Heating (*A*) with Zn dust and HCl, a gas (*F*) is obtained that gives a silver mirror of (*A*) when passed through a heated glass tube. (*B*) turns blue litmus red and finally white.

27. (*A*) and (*B*) are respectively

(a) P_4 (white) and O_2 (b) As (s) and Cl_2
(c) S_8 (rhombic) and O_3 (d) I_2(s) and Cl_2O_6

28. (*C*) and (*D*) are respectively

(a) P_4O_6 and P_4O_{10} (b) $AsCl_3$ and $AsCl_5$
(c) SO_2 and $(SO_3)_2$ (d) I_2O_5 and I_2O_7

29. (*E*) should be

(a) $Hg_2(NO_3)_2$ (b) $Hg(NO_3)_2$
(c) $Pb(NO_3)_2$ (d) $(CH_3COO)_2Pb$

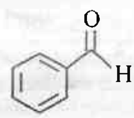
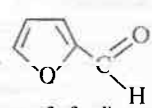
30. The gas (*F*) is

(a) HI (b) PH_3
(c) H_2S (d) AsH_3

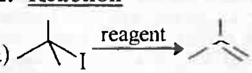
Section - II

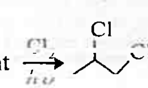
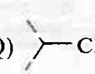
Match the following (Q. No. 31 to 34)

31.

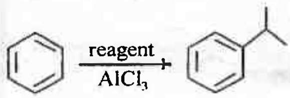
Column I	Column II
(a)  (benzaldehyde)	(P) Canizzaro's reaction
(b) $H_3C-\overset{\overset{O}{\parallel}}{C}-O-C_2H_5$	(Q) Aldol condensation
(c) $H_3C-\overset{\overset{O}{\parallel}}{C}-C_2H_5$	(R) Benzoin condensation
(d)  (furfural)	(S) Claisen's condensation

32. <u>**Reaction**</u> <u>**Reagent**</u>

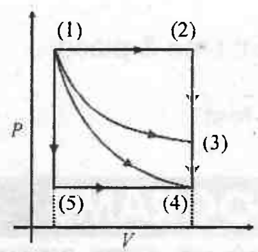
(a)  (P) 

(b) Reagent  (Q) 

(c) $H_3C-\overset{\overset{\large O}{\|}}{C}-H \xrightarrow[\text{(ii) } H^+/H_2O]{\text{(i) reagent}}$ $H_3C-\underset{\underset{\large H}{|}}{\overset{\overset{\large OH}{|}}{C}}-COOH$ (lactic acid) (R) KCN

(d)  (S) Alc. KOH

33. In order to reach from state (1) to (4), different paths are sketched in *P-V* diagram. Choose the correct processes (given in the second column), for the paths stated in the first column. If more than one processes are involved, choose all. It is given that one of the process is isothermal while another is adiabatic.



(a) $(1) \to (2) \to (3) \to (4)$ (P) Isothermal
(b) $(1) \to (3) \to (4)$ (Q) Adiabatic
(c) $(1) \to (4)$ (R) Isobaric
(d) $(1) \to (5) \to (4)$ (S) Isochoric

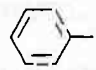
34. Column I **Column II**
(a) $BeCO_3$ (P) thermally most stable
(b) $CaCO_3$ (Q) maximum lattice energy
(c) $MgCO_3$ (R) hydration energy < lattice energy
(d) $BaCO_3$ (S) hydration energy > lattice energy

Section - III

Subjective questions (Q. No. 35 to 38)

35. [A] (i) A colourless cation which on addition of HCl gives white precipitate which disappears on boiling.
(ii) A carbonate which, on heating, gives a yellow solid which turns white on cooling.
[B] A colourless crystalline solid (*A*) is insoluble in water. It dissolves in molten NaOH to give a water soluble product (*B*). Acids, in general, do not attack (*A*) but it dissolves in hydrofluoric acid to give a solution which, when evaporated to dryness, leaves no residue. Identify *A* and *B*.

36. Identify the following species. Give balanced chemical equation for the reaction involved as well.
(i) Green coloured cation which gives green precipitate on addition of NaOH. The precipitate dissolves in excess NaOH.
(ii) Green coloured cation which gives green precipitate on addition of NaOH. The precipitate turns brown on standing.
(iii) Blue coloured cation which gives blue precipitate on addition of NaOH. The precipitate turns black on heating.
(iv) Colourless cations which give an orange coloured precipitate with KI.

37. Four vessels, *A*, *B*, *C* and *D* contain CH_3Li, $-NH_2$, CH_3OH and $CH_3-C\equiv C^-Na^+$, not necessarily in this order. As the solutions are mixed, following observations are made

$A + B \to$ a gas is liberated; $A + C \to$ a gas is liberated
$A + D \to$ no gas is liberated; $B + C \to$ no gas is liberated
$B + D \to$ a gas is liberated; $C + D \to$ no gas is liberated

Given that all hydrocarbons with less than six carbons are gaseous at room temperature; CH_3NH_2 and CH_3-O-CH_3 are also gaseous at room temperature. Identify (*A*)–(*D*) giving reactions and necessary logic.

38. (a) A sample of ozonised oxygen is passed over a bed of $RuO_{3(s)}$ in a broad pipe. As it leaves the pipe at constant pressure of five atmospheres, the following equilibrium may be assumed to be established : $RuO_{3(s)} + O_{3(g)} \rightleftharpoons RuO_{4(g)} + O_{2(g)}$. In flowing and out flowing gaseous mixtures contain 20% and 12.5% of ozone by volume. Estimate K_p for the given reaction at this temperature.
(b) An isothermal vessel contains air saturated with water vapour at a total pressure of 600 torr. Find the pressure in the vessel as its volume is (i) doubled (ii) halved. (Vapour pressure of water = 60 torr at this temperature).

MATHEMATICS

Section - I

Comprehensive questions (Q. No. 39 to 50)

Comprehension - 1

$\{x\}$ and $[x]$ denote the fractional and integral parts of a real number x respectively

Statement : The values of 'α' for which the equation $|x|^2 (|x|^2 - 2\alpha + 1) = 1 - \alpha^2$, has

39. No real roots, when $\alpha \in$

(a) $(-\infty, -1) \cup \left(\frac{5}{4}, \infty\right)$ (b) $(-1, 5/4)$

(c) $(-1, 1)$ (d) none of these.

40. Exactly two real roots, when $\alpha \in$

(a) $(-1, 1)$ (b) $(1, 5/4)$

(c) $(-\infty, -1)$ (d) none of these.

41. Four real roots, $\alpha \in$

(a) $(-1, 1)$ (b) $(-\infty, -1) \cup \left(\frac{5}{4}, \infty\right)$

(c) $(-\infty, -1)$ (d) none of these

42. If $[\alpha] < 0$ then equation have two real roots if $\alpha, \in$

(a) $(-\infty, 1/2]$ (b) $(-\infty, 5/4)$

(c) $(-1, 1)$ (d) none of these

Comprehension - 2

The vertices of a ΔABC lies on a rectangular hyperbola such that the orthocentre of the triangle is (3, 2) and the asymptotes of the rectangular hyperbola are parallel to the coordinate axis. If the two perpendicular tangents of the hyperbola intersect at the point (1, 1)

43. The equation of the asymptotes is

(a) $xy - 1 = x - y$ (b) $xy + 1 = x + y$

(c) $2xy = x + y$ (d) none of these.

44. Equation of the rectangular hyperbola is

(a) $xy = 2x + y - 2$ (b) $2xy = x + 2y + 5$

(c) $xy = x + y + 1$ (d) none of these.

45. Number of real normals that can drawn from the point (1, 1) to the rectangular hyperbola is

(a) 4 (b) 0

(c) 3 (d) 2

46. The ratio of the portion of the intercept of the asymptotes and rectangular hyperbola by a line is

(a) 1 : 2 (b) 3 : 2

(c) 1 : 1 (d) none of these.

Comprehension - 3

If $f(x)$ satisfying the equation,

$$f(x) = x + \int_0^{\log 2} f(y)\, e^x (e^y + e^{-y})\, dy.$$

Now, $f(x)$ can also be written as $f(x) = x + (a + b)e^x$

47. Find the value of a.

(a) $\int_0^{\log 2} f(y)\, dy$ (b) $\int_0^{\log 2} f(y)\, e^y \cdot e^x\, dy$

(c) $\int_0^{\log 2} f(y)\, e^y\, dy$ (d) none of these.

48. Find the value of b.

(a) $\int_0^{\log 2} \log y \;\; dx$ (b) $\int_0^{\log 2} f(y) \;\; e^y\, dy$

(c) $\int_0^{\log 2} f(y)\, e^{-y}\, dy$ (d) none of these.

49. Find the $f(x)$.

(a) $\left(\frac{1 - 3\log 2}{1 + 2\log 2}\right) e^x$ (b) $x + \left(\frac{1 + 2\log 2}{1 - 3\log 2}\right) e^x$

(c) $x + \left(\frac{1 - 3\log 2}{1 + 2\log 2}\right) e^x$ (d) none of these

50. If log 2 taken as base 2, then find x such that $f(x)$ increases.

(a) $(-\infty, 1)$ (b) $\left(-\infty, \log_e \frac{3}{2}\right)$

(c) $\left(-\infty, \log_e \frac{5}{2}\right)$ (d) none of these

Section - II

Match the following (Q. No. 51 to 54)

51. (a) Let $f(x) = \begin{cases} \tan^{-1} x, & |x| > 1 \\ \frac{x^2 - 1}{4}, & |x| < 1 \end{cases}$ (P) -1

then $f(x)$ is not differentiable at x equal to

(b) $f(x) = (x^2 - 4)\,|x^2 - 5x + 6| + \cos|x|$ (Q) 1

is non derivable at x equal to

(c) If $\sin(x + y) = e^{x+y} - 2$, then $\frac{dy}{dx}$ (R) 2

is equal to

Contd. on page no.80

Come here from page 26 and go back

Contd. from page no. 26

(d) Let $f: R \longrightarrow R$ is defined by the equation $f(x+y) = f(x)f(y)\ \forall\ x, y \in R$, $f(0) \neq 0$ and $f'(0) = 2$, then $\dfrac{f'(x)}{f(x)}$ is equal to

(S) 3

(T) -2

52. (a) The sides BC, CA and AB of a triangle ABC are $x + 2y = 1$, $3x + y + 5 = 0$ and $x - y + 2 = 0$. The equation of the altitude through B is

(b) The image of the line $x - 2y = 1$ in the line $x + y = 0$ is

(c) A right angle ABC with sides AB, BC, CA in ratio 5 : 4 : 3 moves such that A and B always lie on the positive x and y axes respectively. The locus of C is

(d) $A(1, 2)$, $B(-1, 5)$ are two vertices of a triangle ABC whose third vertex C lies on the line $2x + y = 2$. The locus of the centroid of the triangle is

(P) $2x - y = 1$

(Q) $2x + y = 3$

(R) $3x - 4y = 0$

(S) $4x + 3y = 4$

(T) $x - 3y + 4 = 0$

53. (a) $\lim\limits_{x \to \infty} x \cos\dfrac{\pi}{8x} \sin\dfrac{\pi}{8x} =$

(b) $\lim\limits_{x \to 0} \dfrac{\tan[-\pi^2]x^2 - [-\pi^2]x^2}{\sin^2(x)} =$

(c) $\lim\limits_{x \to \infty} \sqrt{\dfrac{2x - \sin x + \cos x}{x + \cos^2 x + \sin^2 x}} =$

(d) $\lim\limits_{x \to \infty} e^{\left(\frac{x^n - 1}{n(x-1)}\right)^{\frac{1}{x-1}}} =$

(P) $\dfrac{\pi}{8}$

(Q) $\sqrt{2}$

(R) $\dfrac{8}{\pi}$

(S) $\dfrac{n-1}{2}$

(T) 0

54. Consider a system of three linear equations in three variables x, y, z

$a_1x + b_1y + c_1z + d_1 = 0$

$a_2x + b_2y + c_2z + d_2 = 0$

$a_3x + b_3y + c_3z + d_3 = 0$, which represent planes P_1, P_2 and P_3 respectively

Let $A = \begin{bmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{bmatrix}$ and $B = \begin{bmatrix} a_1 & b_1 & c_1 & d_1 \\ a_2 & b_2 & c_2 & d_2 \\ a_3 & b_3 & c_3 & d_3 \end{bmatrix}$ now match the entries from the following columns:

(a) If rank of A = rank of $B = 3$ then the planes P_1, P_2, P_3

(b) If rank of $A = 2$ and rank of $B = 3$ then the planes P_1, P_2, P_3

(c) If rank of A = rank of $B = 2$ then the planes P_1, P_2, P_3

(d) If rank of A = rank of $B = 1$, then the planes P_1, P_2, P_3

(P) are coincident

(Q) are parallel

(R) from a prism

(S) intersect along a line

(T) intersect in a unique point

Subjective questions (Q. No. 55 to 58)

55. The general value of α such that the line $x\cos\alpha + y\sin\alpha = p$ is a normal to the curve $(x + a)y = c^2$ is

56. A_1 is the area bound by $|y| = 4 - x^2$ and A_2 is the area bounded by $|y| = 4 - x^2$ and $|y| = 3x$ then $\frac{A_2}{A_1}$ is equal to

57. The exhaustive set of values of 'a' for which all the solutions of the inequation $(a-1)x^2 - (a + |a-1| + 2)x + 1 > 0$ are the solution of the inequation $x^2 + 1 > 0$ are

58. $f(x) = \lim_{n\to\infty} x\left[\frac{1}{1\cdot 3} + \frac{2}{1\cdot 3\cdot 5} + \ldots + \frac{n}{1\cdot 3\cdot 5\cdots(2n+1)}\right]$

then $\int_0^4 [f(x)]d(x-[x])$ (where $[\cdot]$ is the greatest integer function) is equal to

ANSWERS

PAPER I

1.	(b)	2.	(b)	3.	(b)	4.	(c)
5.	(d)	6.	(b)	7.	(a)	8.	(a)
9.	(c)	10.	(b)	11.	(a)	12.	(d)
13.	(c)	14.	(a, b, d)	15.	(a,c)	16.	(a,b)
17.	(a,b)	18.	(b)	19.	(b)	20.	(b)
21.	(d)	22.	(b)	23.	(d)	24.	(b)
25.	(b)	26.	(b)	27.	(c)	28.	(b)
29.	(a)	30.	(a)	31.	(b)	32.	(d)
33.	(a,d)	34.	(a,c)	35.	(d)	36.	(a,c)
37.	(a,b)	38.	(b,c)	39.	(b,c)		
40.	(a,b,c,d)	41.	(d)	42.	(c)	43.	(c)
44.	(a)	45.	(b)	46.	(c)	47.	(b)
48.	(c)	49.	(a)	50.	(c)	51.	(c)
52.	(a)	53.	(a,b,c,d)	54.	(a,b)	55.	(a,b)
56.	(c,d)	57.	(a,b,c)	58.	(a,c)	59.	(a,c)
60.	(a,b,c,d)						

PAPER II

1. (c) 2. (d) 3. (b) 4. (d)
5. (a) 6. (d) 7. (d) 8. (a)
9. (c) 10. (a)
11. (a) R (b) P (c) Q
12. (a) (P, R) (b) (P, R) (c) (S, Q) (d) (S, Q)
13. (a) Q (b) P (c) R
14. (a) R (b) Q (c) Q (d) P
15. 50 cm 16. 30° 17. 4.7×10^{-3} mm
18. $T = \frac{\pi\omega\mu}{2h\sin\theta} r_0^4$
19. (c) 20. (c) 21. (d) 22. (c)
23. (a) 24. (a) 25. (c) 26. (a)
27. (b) 28. (b) 29. (a) 30. (d)
31. (a) (P, R) (b) S (c) Q (d) (P, R)
32. (a) (R, S) (b) (P, Q) (c) R (d) (P, Q)
33. (a) (R, S) (b) (P, S) (c) Q (d) (R, S)
34. (a) (Q, S) (b) R (c) R (d) (P, R)
35. (a) (i) Pb, (ii) $ZnCO_3$,
(b) A = SiO_2 or B_2O_3,
B = Na_2SiO_3 or $NaBO_2$
36. (i) Cr (ii) Fe (iii) Cu (iv) Hg_2^{2+}
37. A = CH_3OH;
B = CH_3Li;
C = $CH_3C \equiv C^-Na^+$;
D = $Ph-NH_2$
38. (a) 1.875 atm; (b) (i) 300 torr, (ii) 1140 torr 39. (a)
40. (a) 41. (d) 42. (a) 43. (b)
44. (c) 45. (d) 46. (b) 47. (c)
48. (c) 49. (c) 50. (b)
51. (a) (P, Q) (b) S (c) Q (d) R
52. (a) T (b) P (c) R (d) Q
53. (a) P (b) T (c) R (d) Q
54. (a) T (b) R (c) S (d) P
55. $\left(2n\pi+\frac{\pi}{2}, (2n+1)\pi\right) \cup \left(2n\pi+\frac{3\pi}{2}, (2n+2)\pi\right)$ 56. 19/64
57. $\alpha \in \phi$ or no value 58. 2

AIIMS | CBSE | DPMT | AFMC | VMMC | EAMCET | WB-JEE | BHU | CMC

2007 Medical Entrance Exam

UP CPMT | CET Karnataka

Practice Test Paper

Manipal PMT | JIPMER

MP PMT | MGIMS | PMDT Bihar | PMT Haryana | Kerala PMT | Raj. PMT | TNPCEE

1. Pressure gradient has the same dimension as that of
(a) velocity gradient (b) potential gradient
(c) energy gradient (d) none of these.

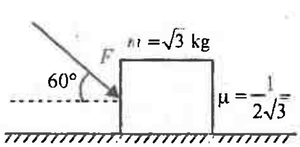
2. A food packet is released from a helicopter which is rising steadily at 2 ms^{-1}. After two seconds, the velocity of the packet will be
(a) 17.6 ms^{-1} (b) 5.6 ms^{-1}
(c) 8.6 ms^{-1} (d) 4.6 ms^{-1}.

3. A particle moves so that the displacement x at time t is given by $x^2 = 1 + t^2$. What is its acceleration?
(a) $\frac{1}{x}$ (b) $\frac{t^2}{x^3}$ (c) $\frac{1}{x} - \frac{t^2}{x^3}$ (d) $\frac{2t^2}{x^3}$.

4. A ball is thrown up at an angle of 30° with the horizontal. If R and H represent its horizontal range and maximum height reached, then
(a) $R = 2H$ (b) $R = H$
(c) $R = H/2$ (d) $R = 4\sqrt{3}H$.

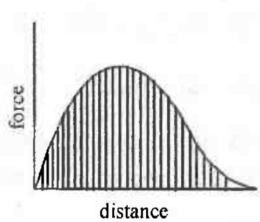
5. In a rocket of mass 1000 kg fuel is consumed at a rate of 40 kg/s. The velocity of the gas ejected from the rocket is 5×10^4 m/s. The thrust on the rocket is
(a) 2×10^3 N (b) 5×10^4 N
(c) 2×10^6 N (d) 2×10^8 N.

6. What is the maximum value of the force F such that the block shown in the figure does not move?



(a) 20 N (b) 10 N
(c) 12 N (d) 15 N.

7. Which one of the following physical quantities is represented by the shaded area in the given graph?



(a) torque
(b) impulse
(c) power (d) work done.

8. If the momentum of a body increases by 50% its kinetic energy will increase by
(a) 50% (b) 100% (c) 125% (d) 150%.

9. A 2.5 kg mass moving at a speed of 15 m/s collides with 5 kg object initially at rest. They stick together. Find the velocity of the combination after the collision.
(a) 15 m/s (b) 5 m/s
(c) 20 m/s (d) none of these.

10. The moment of inertia of a thin circular disc of mass M and radius R is minimum about its axis passes
(a) through centre and perpendicular to the surface
(b) through centre but parallel to the surface
(c) tangential but perpendicular to the surface
(d) tangential but parallel to the surface.

11. If the earth shrinks to half of its radius without change in mass, the duration of the day will be
(a) 48 hours (b) 24 hours
(c) 12 hours (d) 6 hours.

12. For a satellite escape velocity is 11 km/s. If the satellite is launched at an angle of 60° with the vertical, then escape velocity will be
(a) 11 km/s (b) $11\sqrt{3}$ km/s
(c) $11/\sqrt{3}$ km/s (d) 33 km/s.

13. The time period of a satellite of earth is 5 hours. If the separation between the earth and the satellite is increased to 4 times the previous value, the new time period will become
(a) 20 hours (b) 10 hours
(c) 80 hours (d) 40 hours.

14. A wire of length L and cross-sectional area A is made of a material of Young's modulus Y. If the wire is stretched by the amount x, the work done is

(a) $\frac{YAx^2}{2L}$ (b) $\frac{YAx}{2L^2}$ (c) $\frac{2YAx^2}{L}$ (d) $\frac{YAx^2}{L}$.

15. A wooden cylinder floats in water with two-thirds of its volume inside water. The density of wood is

(a) $\frac{1000}{3}$ kg/m^3 (b) $\frac{2000}{3}$ kg/m^3

(c) $\frac{500}{3}$ kg/m^3 (d) 250 kg/m^3.

16. A rectangular vessel when full of water takes 10 minutes to be emptied through an orifice in its bottom. How much time will it take to be emptied when half-filled with water?

(a) 9 minutes (b) 7 minutes

(c) 5 minutes (d) 3 minutes.

17. At the same temperature the mean kinetic energies of molecules of hydrogen and oxygen are in the ratio

(a) 1 : 1 (b) 1 : 16 (c) 8 : 1 (d) 16 : 1.

18. Universal gas constant is equal to

(a) C_P/C_V (b) $C_P - C_V$

(c) $C_P + C_V$ (d) C_V/C_P.

19. The temperature of 100 g of water is to be raised from 24°C to 90°C by adding steam to it. The mass of the steam required for this purpose should be

(a) 5 g (b) 10 g (c) 12 g (d) 15 g.

20. A quantity of perfect gas at 15°C is adiabatically compressed to one-fourth of its volume. The final temperature is ($\gamma = 1.4$, $(4)^{0.4} = 1.74$)

(a) 200°C (b) 228°C (c) 300°C (d) 328°C.

21. If the temperature of a perfectly black body measured in Kelvin is doubled, then the energy radiated per second becomes

(a) twice the original value

(b) 16 times the original value

(c) half the original value

(d) 4 times the original value.

22. A spring-mass system oscillates with a frequency υ. If it is taken in an elevator slowly accelerating upward, the frequency will

(a) increase (b) decrease

(c) remains same (d) becomes zero.

23. What is the maximum acceleration of the particle executing the simple harmonic motion?

$$y = 2\sin\left[\frac{\pi t}{2} + \phi\right] \text{ where 2 is in cm}$$

(a) $\frac{\pi}{2}$ cm/s^2 (b) $\frac{\pi^2}{2}$ cm/s^2

(c) $\frac{\pi}{4}$ cm/s^2 (d) $\frac{\pi^2}{4}$ cm/s^2.

24. To increase the period of a pendulum by 10 percent, the length should be increased by (in percentage)

(a) 21 (b) 11 (c) 10.5 (d) 10.

25. For the travelling harmonic wave

$$y = 2.0\cos(10t - 0.0080x + 0.35)$$

where x and y are in cm and t in s. What is the phase difference between oscillatory motion at two points separated by a distance of 4 m?

(a) 1.2 rad (b) 2.5 rad

(c) 3.2 rad (d) 4.2 rad.

26. A railway engine and a car are moving on parallel tracks in opposite directions with speed of 144 km hr^{-1} and 72 km hr^{-1}, respectively. The engine is continuously sounding a whistle of frequency 500 Hz. The velocity of sound is 340 ms^{-1}. The frequency of sound heard in the car when the car and the engine approaching each other will be

(a) 200 Hz (b) 300 Hz (c) 400 Hz (d) 600 Hz.

27. A cube of side b has a charge q at each of its vertices. The electric field due to this charge array at the centre of the cube is

(a) zero (b) $\frac{q}{\sqrt{3}\pi\varepsilon_0 b^2}$

(c) $\frac{q}{\varepsilon_0 b^2}$ (d) $\frac{q}{8\varepsilon_0 b^2}$.

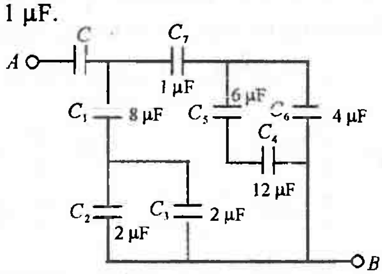
28. There is a solid sphere of radius R having uniformly distributed charge throughout it. What is the relation between electric field E and distance r from the centre ($r < R$)?

(a) $E \propto r^{-2}$ (b) $E \propto r^{-1}$

(c) $E \propto r$ (d) $E \propto r^2$.

29. Find the value of the capacitance C as shown in the figure, if the equivalent capacitance between point

A and B is to be 1 μF.



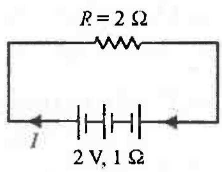
(a) $\frac{23}{32}$ μF

(b) $\frac{32}{23}$ μF

(c) $\frac{20}{23}$ μF

(d) $\frac{23}{20}$ μF.

30. In an electric circuit shown, each cell has an e.m.f. of 2 V and internal resistance of 1 Ω. The external resistance is 2 Ω. The value of the current I is (in A)



(a) 1.2 (b) 2 (c) 3 (d) 0.4

31. At what temperature will the resistance of a copper wire become three times its value at 0°C? (Temperature coefficient of resistance for copper = 4×10^{-3} per °C).
(a) 400°C (b) 450°C (c) 500°C (d) 550°C.

32. A silver and a copper voltameter are connected in series with a 12.0 volt battery of negligible internal resistance. 0.806 g of silver is deposited in half an hour in the silver voltameter. The mass of copper deposited in the copper voltameter during the same period is (Given:ECE of silver = 1.12×10^{-8} kg C^{-1}, ECE of copper = 6.6×10^{-7} kg C^{-1}).
(a) 42 g (b) 45 g (c) 48 g (d) 50 g.

33. An electrical bulb rated for 500 W at 100 V is used in a circuit having a 200 V supply. The resistance that one must put in series with the bulb, so that the bulb delivers 500 W is
(a) 10 Ω (b) 20 Ω (c) 30 Ω (d) 40 Ω.

34. Magnetic field intensity in the centre of coil of 50 turns, radius 0.5 m and carrying a current of 2 A is
(a) 0.5×10^{-5} T (b) 1.25×10^{-4} T
(c) 3×10^{-5} T (d) 4×10^{-5} T.

35. Relative permeability of iron is 5500. Its magnetic susceptibility is
(a) 5500×10^{7} (b) 5499
(c) 5501 (d) 5500×10^{-7}.

36. An aeroplane with a wingspan of 30 m flies at horizontal speed of 100 ms^{-1} in a region where the vertical component of the magnetic field due to earth is 5.0×10^{-5} Wb m^{-2}. What is the potential difference between the tips of the wings?
(a) 0.15 V (b) 0.3 V (c) 0.4 V (d) 0.5 V.

37. Alternating current cannot be measured by D.C. ammeter because
(a) A.C. cannot pass through D.C. ammeter
(b) A.C. changes direction
(c) average value of current for complete cycle is zero
(d) D.C. ammeter will get damaged.

38. A parallel plate capacitor has circular plates, each of radius 5 cm. It is being charged so that electric field in the gap between its plates rises steadily at the rate of 10^{12} V m^{-1} s^{-1}. Then the displacement current will be
(a) 0.02 A (b) 0.04 A
(c) 0.07 A (d) 0.09 A.

39. The distance that a beam of light of wavelength 500 nm can travel without significant broadening, if the diffracting aperture is 3 mm wide is
(a) 10 m (b) 15 m (c) 18 m (d) 20 m.

40. The radii of curvature of the surfaces of double convex lens are 20 cm and 40 cm respectively and its focal length is 20 cm. The refractive index of the material of the lens will be
(a) 4/3 (b) 5/3 (c) 3/4 (d) 3/5.

41. An object is placed 10 cm in front of a lens forms a real image three times magnified. The focal length of the lens is
(a) 6.5 cm (b) 7.5 cm (c) 8.5 cm (d) 9.5 cm.

42. How many kV potential is to be applied on X-ray tube so that minimum wavelength of emitted X-rays may be 1 Å? ($h = 6.625 \times 10^{-34}$ J-s)
(a) 12.42 kV (b) 12.84 kV
(c) 11.98 kV (d) 10.78 kV.

43. The kinetic energy of α-particle is 10^{-12} joule. It shows a recoil scattering with gold nucleus ($Z = 79$). What will be the maximum radius of the nucleus?
(a) 2.54×10^{-14} m (b) 3.64×10^{-14} m
(c) 1.22×10^{-14} m (d) 1.81×10^{-14} m.

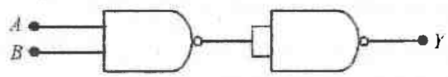
44. A deuteron is bombarded on ${}_8O^{16}$ nucleus then

α-particle is emitted then product nucleus is
(a) $_7N^{13}$ (b) $_5B^{10}$ (c) $_2Be^9$ (d) $_7N^{14}$.

45. The reverse process of pair production is called
(a) annihilation of matter
(b) α-decay (c) radioactivity
(d) carbon-nitrogen cycle.

46. Which of the following has the same mass as that of electron?
(a) proton (b) hydrogen atom
(c) positron (d) neutron.

47. The given circuit performs the logic function of



(a) NAND gate (b) OR gate
(c) XOR gate (d) AND gate.

48. In a common base circuit, the collector current changes by 0.04 mA when the collector-base voltage is changed by 0.5 volt. Output resistance in kΩ is
(a) 6 (b) 20 (c) 16 (d) 12.5

49. A potential barrier of 0.50 V exists across a *p-n* junction. If the depletion region is 5.0×10^{-7} m wide, the intensity of the electric field in this region is
(a) 1.0×10^6 V/m (b) 1.0×10^5 V/m
(c) 2.0×10^5 V/m (d) 2.0×10^6 V/m.

50. Which of the following has maximum energy?
(a) radiowaves (b) infra-red waves
(c) ultraviolet rays (d) microwaves.

SOLUTIONS

1. **(d) :** Pressure gradient $= \dfrac{P}{x} = \dfrac{F/A}{x} = \dfrac{F}{Ax} = \dfrac{\mathrm{MLT^{-2}}}{\mathrm{L^2L}}$
$= [\mathrm{ML^{-2}T^{-2}}]$.

Velocity gradient $= \dfrac{v}{x} = \dfrac{\mathrm{LT^{-1}}}{\mathrm{L}} = [\mathrm{T^{-1}}]$

Energy gradient $= \dfrac{E}{x} = \dfrac{\mathrm{ML^2T^{-2}}}{\mathrm{L}} = [\mathrm{MLT^{-2}}]$

Potential gradient $= \dfrac{V}{x} = \dfrac{W/q}{x} = \dfrac{W}{qx}$

$= \dfrac{\mathrm{ML^2T^{-2}}}{\mathrm{ATL}} = [\mathrm{MLT^{-3}A^{-1}}]$.

2. **(a) :** The initial velocity of the food packet will be equal to that of the helicopter, but in the opposite direction.

Hence, $u = -2\ \mathrm{ms^{-1}}$, $g = 9.8\ \mathrm{ms^{-2}}$, $t = 2$ s

∴ Final velocity, $v = u + gt$
$= -2 + 9.8 \times 2 = 17.6\ \mathrm{ms^{-1}}$.

3. **(c) :** $x^2 = 1 + t^2$. Therefore $2x\dfrac{dx}{dt} = 2t$

i.e. $x\dfrac{dx}{dt} = t$.

Differentiating with respect to time again, we get

$$\left(\frac{dx}{dt}\right)^2 + x\frac{d^2x}{dt^2} = 1$$

$$\therefore\ \frac{d^2x}{dt^2} = \frac{1}{x}\left[1-\left(\frac{dx}{dt}\right)^2\right] = \frac{1}{x} - \frac{t^2}{x^3}.$$

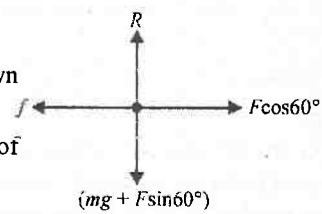
4. **(d) :** $R = \dfrac{u^2\sin 2\theta}{g} = \dfrac{u^2}{g}\sin 60° = \dfrac{u^2}{g}\dfrac{\sqrt{3}}{2}$

$$H = \frac{u^2\sin^2\theta}{2g} = \frac{u^2\sin^2 30°}{2g} = \frac{u^2}{8g}$$

Hence $\dfrac{R}{H} = \dfrac{\sqrt{3}}{2} \times 8 = 4\sqrt{3} \Rightarrow R = 4\sqrt{3}H$.

5. **(c) :** $F = v\dfrac{dM}{dt} = 5 \times 10^4 \times 40 = 2 \times 10^6$ N.

6. **(a) :** Free body diagram of the block shown by a dot is drawn here.



For vertical equilibrium of the block,

$R = mg + F\sin 60°$

$$R = \sqrt{3}g + \frac{F\sqrt{3}}{2}$$

For no motion along the horizontal,

$f > F\cos 60°$ or $\mu R > F\cos 60°$

or $\mu\left(\sqrt{3}g + \dfrac{F\sqrt{3}}{2}\right) \geq \dfrac{F}{2}$

$\dfrac{\sqrt{3}}{2\sqrt{3}}\left(g + \dfrac{F}{2}\right) \geq \dfrac{F}{2}$ or $g \geq \dfrac{F}{2}$

or, $F \leq 2g$ or 20 N.

7. **(d) :** Work done $= \int F dx$.

8. **(c) :** Kinetic energy, $K = \dfrac{p^2}{2m}$ or $K \propto p^2$

When a momentum of a body is increased by 50%, its momentum become p'

or, $p' = p + \frac{50}{100}p = \frac{3}{2}p$

or, $\frac{K'}{K} = \left(\frac{p'}{p}\right)^2 = \left(\frac{\frac{3}{2}p}{p}\right)^2 = \frac{9}{4}$

Percentage increase in kinetic energy

$= \frac{K' - K}{K} \times 100 = \left(\frac{K'}{K} - 1\right) \times 100$

$= \left(\frac{9}{4} - 1\right) \times 100 = 125\%.$

9. (b) : Applying the principle of conservation of linear momentum,

$2.5 \times 15 + 5 \times 0 = (2.5 + 5)\, v$

$\therefore \quad v = \frac{2.5 \times 15}{7.5} = 5$ m/s.

10. (b) : Moment of inertia of a thin circular disc about an axis passes through centre and perpendicular to the surface = $MR^2/2$

Moment of inertia of a thin circular disc about an axis passes through centre but parallel to the surface = $MR^2/4$.

Moment of inertia of a thin circular disc about an axis passes tangential but perpendicular to the surface = $(3/2)MR^2$

Moment of inertia of a thin circular disc about an axis passes tangential but parallel to the surface = $(5/4)MR^2$.

11. (d) : Radius of earth is halved, so its moment of inertia becomes one fourth. Hence to conserve the angular momentum, angular speed becomes four times.

$\therefore \quad \frac{\omega_1}{\omega_2} = \frac{T_2}{T_1}$

or $\quad T_2 = \left(\frac{\omega_1}{\omega_2}\right) T_1$

$T_2 = \left(\frac{\omega_1}{4\omega_1}\right) T_1 = \frac{T_1}{4} = \frac{24}{4} = 6$ hours ($\because T_1 = 24$ hours)

12. (a) : Escape velocity $v_e = \sqrt{\frac{2GM}{R}}$ where M – mass of earth, R – radius of earth.

i.e. Escape velocity of a satellite is independent of the angle of projection.

13. (d) : From Kepler's law of periods, we have

$T^2 \propto R^3 \quad \Rightarrow \quad \left(\frac{T_2}{T_1}\right) = \left(\frac{R_2}{R_1}\right)^{3/2}$

Substituting $R_2 = 4R_1$, $T_1 = 5$ hr, we get

$T_2 = 40$ hours.

14. (a) : $W = \int_0^x F dx' = \frac{YA}{L}\int_0^x x' dx' = \frac{YAx^2}{2L}$.

15. (b) : $\frac{\text{Immersed volume}}{\text{Total volume}} = \frac{\text{density of solid}}{\text{density of liquid}}$

or. $\frac{2/3}{1} = \frac{\rho_s}{1000}$ or $\rho_s = \frac{2000}{3}$ kg/m^3.

16. (b) : The velocity of outflow through an orifice is given by $v = \sqrt{2gh}$.

Average velocity of outflow = $\frac{1}{2} \times \sqrt{2gh}$

If A be the area of cross-section of the orifice, then time of outflow for liquid of volume V is

$t = \frac{V}{A \times (1/2)\sqrt{2gh}}$

In the second case volume is $V/2$ and height is $h/2$.

Therefore, $t' = \frac{V/2}{A \times (1/2) \times \sqrt{2g(h/2)}}$

$\therefore \quad t' = \frac{t}{\sqrt{2}} = \frac{10}{\sqrt{2}} =$ 7 minutes.

17. (a) : Mean kinetic energy of a molecule in an ideal gas is proportional to the absolute temperature and independent of the kind of gas.

18. (b) : $C_P - C_V = R$

19. (c) : Let m be the mass of steam required, then according to the principle of calorimetry,

Heat lost by steam = heat gained by water

or $\quad mL + ms(100 - 90) = 100 \times s \times (90 - 24)$

or $\quad m[540 + 1 \times 10] = 100 \times 1 \times 66$

or $\quad m = \frac{100 \times 1 \times 66}{550} = 12$ g.

20. (b) : Given : $T_1 = 15°C = (273 + 15) = 288$ K

$\frac{V_2}{V_1} = \frac{1}{4}, \quad \gamma = 1.4$

For adiabatic change, $TV^{\gamma - 1}$ = constant

or $\quad T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1} \quad$ or $\quad \frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$

Substituting the values, $\frac{T_2}{288} = (4)^{1.4-1}$

or, $T_2 = 288 \times (4)^{0.4} = 288 \times 1.74 = 501$ K

$= (501 - 273)°C = 228°C$.

21. (b) : According to Stefan's law $E \propto T^4$.

Therefore E becomes $(2)^4$ times *i.e.*, 16 times.

22. (c) : Frequency of spring-mass system is given by

$$\upsilon = \frac{1}{2\pi}\sqrt{\frac{k}{M}}$$

$\Rightarrow$ υ is independent of g.

23. (b) : The standard equation of simple harmonic motion is given by

$$y = A\sin(\omega t + \phi) \quad \text{... (i)}$$

Given equation is

$$y = 2\sin\left[\frac{\pi}{2}t + \phi\right] \quad \text{... (ii)}$$

Comparing equation (ii) with (i), we get

$\omega = \pi/2, \;\; A = 2.$

Now, maximum acceleration is given by

$$a_{\max} = \omega^2 A = \left(\frac{\pi}{2}\right)^2 \times 2 = \frac{\pi^2}{2}\,\text{cm/s}^2.$$

24. (a) : Time period of a simple pendulum is given by

$$T = 2\pi\sqrt{\frac{l}{g}} \;\Rightarrow\; T \propto \sqrt{l}$$

or, $\dfrac{T_2}{T_1} = \sqrt{\dfrac{l_2}{l_1}}$

Substituting $T_2 = T_1 + 10\%$ of $T_1 = T_1 + \dfrac{10}{100}T_1$

$$T_2 = \frac{11}{10}T_1, \text{ or } \frac{T_2}{T_1} = \frac{11}{10} = \sqrt{\frac{l_2}{l_1}}$$

or, $\dfrac{121}{100} = \dfrac{l_2}{l_1}$ or $\dfrac{l_2}{l_1} = 1.21$ or $l_2 = 1.21l_1$

Hence, percentage increase in length

$$= \frac{l_2 - l_1}{l_1}\times 100 = \frac{1.21l_1 - l_1}{l_1}\times 100$$

$= 0.21 \times 100 = 21\%.$

25. (c) : The given equation of harmonic wave is

$y = 2.0\cos(10t - 0.0080x + 0.35)$

The general equation of harmonic wave is

$$y = a\cos\left[2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right) - \phi\right]$$

Comparing the two equations we get, $\dfrac{2\pi}{\lambda} = 0.0080$

or, $\lambda = \dfrac{2\pi}{0.0080}\,\text{cm} = \dfrac{2\pi}{0.0080\times 100}$ m

Phase difference $= \dfrac{2\pi}{\lambda}\times$ path difference

$$= \frac{2\pi}{2\pi}\times 0.0080 \times 100 \times 4$$

$= 3.2$ rad

26. (d) : Given that $v_s = 144$ km hr^{-1}

$$= \frac{144\times 1000}{60\times 60}\,\text{ms}^{-1} = 40\,\text{ms}^{-1}$$

$$v_o = 72\,\text{kmhr}^{-1} = \frac{72\times 1000}{60\times 60}\,\text{ms}^{-1} = 20\,\text{ms}^{-1}$$

$\upsilon = 500$ Hz, $v = 340$ ms^{-1}

When the car and the engine are approaching each other,

$$\upsilon' = \frac{v + v_o}{v - v_s}\upsilon = \frac{340 + 20}{340 - 40}\times 500$$

$$= \frac{360}{300}\times 500 = 600\text{ Hz}.$$

27. (a) : Electric field at the centre due to two charges placed at opposite vertices will be equal and opposite and hence resultant electric field will be zero. Since all the eight charges are placed in pairs at opposite vertices, the resultant electric field due to all the eight charges will be zero.

28. (c) : Electric field of a solid sphere of radius R having uniformly distributed charge is given by

$$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2} \text{ for } r > R \text{ [outside the sphere]}$$

$$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{R^2} \text{ for } r = R \text{ [on the surface of the sphere]}$$

$$E = \frac{1}{4\pi\varepsilon_0}\frac{qr}{R^3} \text{ for } r < R \text{ [inside the sphere].}$$

29. (b) : Capacitors C_2 and C_3 form a parallel combination, their equivalent capacitance

$C_8 = C_2 + C_3 = 2 + 2 = 4\ \mu$F.

Capacitors C_4 and C_5 form a series combination, their equivalent capacitance C_9 is given by

$$\frac{1}{C_9} = \frac{1}{C_4} + \frac{1}{C_5} = \frac{1}{12} + \frac{1}{6} = \frac{1}{4} \text{ or, } C_9 = 4\ \mu\text{F}.$$

Given network now reduces to as shown in figure (i).

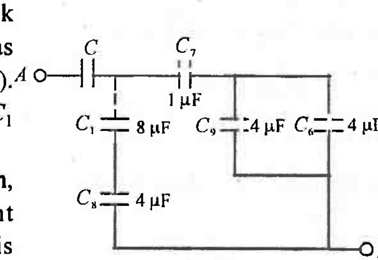


fig. (i)

Now, capacitors C_1 and C_8 form a series combination, their equivalent capacitance C_{10} is given by

$$\frac{1}{C_{10}} = \frac{1}{C_1} + \frac{1}{C_8} = \frac{1}{8} + \frac{1}{4} = \frac{3}{8} \text{ or, } C_{10} = \frac{8}{3}\ \mu\text{F}.$$

Capacitors C_6 and C_9 form a parallel combination, their equivalent capacitance,

$C_{11} = C_6 + C_9 = 4 + 4 = 8\ \mu F.$

Given network now reduces to as shown in figure (ii).

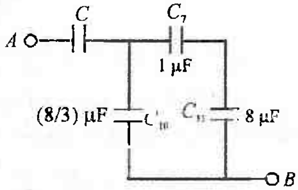


fig. (ii)

Now, capacitors C_7 and C_{11} form a series combination, their equivalent capacitance C_{12} is given by

$$\frac{1}{C_{12}} = \frac{1}{C_7} + \frac{1}{C_{11}} = \frac{1}{1} + \frac{1}{8} = \frac{9}{8} \quad \text{or,} \quad C_{12} = \frac{8}{9}\ \mu F.$$

Given network now reduces to as shown in figure (iii).

Now capacitors C_{10} and C_{12} form a parallel combination, their equivalent capacitance is given by

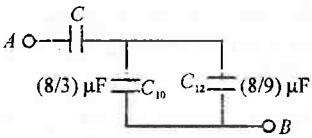


fig. (iii)

$$C_{13} = C_{10} + C_{12} = \frac{8}{3} + \frac{8}{9} = \frac{32}{9}\ \mu F.$$

Given network now reduces to as shown in figure.

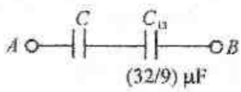


fig. (iv)

Finally, capacitors C and C_{13} form a series combination, their equivalent capacitance is given as 1 μF. Hence we have

$$\frac{1}{1} = \frac{1}{C} + \frac{1}{C_{13}} \quad \text{or} \quad \frac{1}{C} = 1 - \frac{1}{C_{13}} = 1 - \frac{9}{32} = \frac{23}{32}$$

or $\quad C = \frac{32}{23}\ \mu F.$

30. (d) : Net e.m.f. $E = 2$ V

$$I = \frac{2}{2+3} = 0.4 \text{ A}.$$

31. (c) : $R_t = R_0(1 + \alpha t)$

i.e, $\frac{R_t}{R_0} = 1 + \alpha t$. Hence $R_t / R_0 = 3$

$\therefore\ 3 = 1 + 4 \times 10^{-3} \times t$

This gives $t = \frac{1}{2} \times 10^3 = 500°C.$

32. (c) : Given that $m_1 = 0.806$ g $= 0.806 \times 10^{-3}$ kg

$t = 30$ min $= 30 \times 60$ s

$Z_1 = 1.12 \times 10^{-8}$ kg C^{-1}, $Z_2 = 6.6 \times 10^{-7}$ kg C^{-1}

According to Faraday's second law of electrolysis,

$$\frac{m_1}{m_2} = \frac{Z_1}{Z_2}$$

or, $$m_2 = m_1 \times \frac{Z_2}{Z_1} = \frac{0.806 \times 10^{-3} \times 6.6 \times 10^{-7}}{1.12 \times 10^{-8}} \text{ kg}$$

$= 47.5 \times 10^{-3}$ kg $= 48$ kg.

33. (b) : Given $P = 500$ W, $V = 100$ V, $V' = 200$ V

Power of the bulb, $P = V^2/R$

$\therefore$ Resistance of the bulb,

$$R = \frac{V^2}{P} = \frac{100 \times 100}{500}\ \Omega = 20\ \Omega.$$

Current through the bulb, $I = \frac{V}{R} = \frac{100}{20} = 5$ A.

When the bulb is used in 200 V supply to give the same power of 500 W, the current will remain 5 A. Hence safe resistance of the circuit will be

$$R' = \frac{V'}{I} = \frac{200}{5} = 40\ \Omega.$$

Hence the resistance to be put in series with the bulb $= R' - R = 40 - 20 = 20\ \Omega.$

34. (b) : The magnetic field intensity at a centre of a coil of radius R, having N turns carrying a current I is given by $B = \frac{\mu_0}{4\pi}\frac{2\pi NI}{R}$.

$$B = \frac{\mu_0 \times 2\pi \times 50 \times 2}{4\pi \times 0.5} = 1.25 \times 10^{-4} \text{ T}$$

35. (b) : Magnetic susceptibility is given by

$$\frac{\mu}{\mu_0} = 1 + \chi_m \qquad \text{or,} \quad \mu_r = 1 + \chi_m$$

$\Rightarrow\ \chi_m = \mu_r - 1$

Substituting $\mu_r = 5500$, we get $\chi_m = 5499$.

36. (a) : Wing of the aeroplane can be considered as a straight conductor moving at right angles to the direction of magnetic field. Then, potential difference between the tips of the wings = induced e.m.f. = Blv

Here, $B = 5.0 \times 10^{-5}$ Wb m^{-2}, $l = 30$ m, $v = 100$ ms^{-1}

$\therefore$ Potential difference $= 5.0 \times 10^{-5} \times 30 \times 100$

$= 0.15$ volt.

37. (c)

38. (c) : Given $r = 5.0$ cm $= 0.05$ m

$$\frac{dE}{dt} = 10^{12}\ \text{V m}^{-1}\ \text{s}^{-1}$$

$\varepsilon_0 = 8.85 \times 10^{-12}$ C^2 N^{-1} m^{-2} (constant)

The displacement current is given by

$$I_d = \varepsilon_0 \frac{d\phi_E}{dt} = \varepsilon_0 \frac{d}{dt}(EA) = \varepsilon_0 A \frac{dE}{dt}$$

$$= \varepsilon_0 \cdot \pi r^2 \frac{dE}{dt}$$

$= 8.85 \times 10^{-12} \times 3.14 \times (0.05)^2 \times 10^{12}$ A

$= 0.07$ A.

39. (c) : The distance upto which a beam of light can travel without significant broadening, is called Fresnel distance and its value is given by $D_F = \frac{a^2}{\lambda}$

where a is the size of the aperture

Given, $a = 3$ mm $= 3 \times 10^{-3}$ m,

$\lambda = 500$ nm $= 500 \times 10^{-9}$ m

Hence, $D_F = \frac{(3\times10^{-3})^2}{500\times10^{-9}}$ m $= 18$ m.

40. (b) : $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

Given, $f = 20$ cm, $R_1 = 20$ cm, $R_2 = -40$ cm

$\therefore \frac{1}{20} = (\mu-1)\left(\frac{1}{20}+\frac{1}{40}\right) = (\mu-1)\left(\frac{3}{40}\right)$

or, $(\mu - 1) = \frac{2}{3}$ or $\mu = \frac{5}{3}$.

41. (b) : Given $u = -10$ cm, $m = -3$

Since $m = v/u$. $\therefore$ $v/u = -3$ or $v = -3u = 30$ cm.

$\therefore \frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

or $\frac{1}{f} = \frac{1}{30} - \frac{1}{-10} = \frac{1}{30} + \frac{1}{10} = \frac{4}{30}$

or $f = \frac{30}{4} = 7.5$ cm.

42. (a) : $\lambda_{min} = \frac{hc}{Ve} = \frac{1.242\times10^{-6}(\text{V.m})}{V(\text{volt})}$

Given : $\lambda_{min} = 1 \times 10^{-10}$ m

$\therefore V = 12.42$ kV.

43. (b) : $r = \frac{1}{4\pi\varepsilon_0}\frac{2Ze^2}{K}$

where K is the kinetic energy of α-particle

Given $Z = 79$, $e = 1.6 \times 10^{-19}$ C and $K = 10^{-12}$ J.

$$r = \frac{9\times10^9\times2\times79\times(1.6\times10^{-19})^2}{10^{-12}}$$

$= 3.64 \times 10^{-14}$ m

44. (d) : ${}_8O^{16} + {}_1H^2 \rightarrow {}_7N^{14} + {}_2He^4$

deuteron (α-particle)

45. (a)

46. (c) : An antiparticle has charge of equal magnitude but of opposite sign of a particle and same mass of a particle. Positron is the antiparticle of an electron. Therefore positron has the same mass as that of electron.

47. (d) : $Y = \overline{\overline{A}\cdot\overline{B}} = A \cdot B$.

48. (d) : In a common base circuit, output resistance is given by

$$R_{out} = \frac{(\Delta V)_{CB}}{(\Delta I)_C}$$

Substituting $(\Delta V)_{CB} = 0.5$ V, $(\Delta I)_C = 0.04$ mA, we get

$R_{out} = 12.5$ kΩ.

49. (a) : Electric field is defined as potential gradient

$\Rightarrow E = V/r$

Substituting $V = 0.50$ V, $r = 5.0 \times 10^{-7}$ m, we get

$E = 1.0 \times 10^6$ V/m.

50. (c) : Smaller the wavelength, higher is the energy. ■

Practice Paper for

WB-JEE 2007

According to New Pattern

1. The equation of projectile is $y=\sqrt{3}x-\frac{1}{2}gx^2$. The velocity of projection is

(a) 1 m/sec (b) 2 m/sec
(c) 3 m/sec (d) 4 m/sec.

2. Consider a particle initially moving with a velocity of 5 m/sec starts decelerating at a constant rate of 2 m/sec^2. The distance travelled in the third second is

(a) 0 m (b) 0.25 m
(c) 0.5 m (d) none of these.

3. A man is standing in a lift feels lightlessness. The lift is

(a) descending (b) ascending
(c) may ascend or descent
(d) data inadequate.

4. A block is placed on a rough floor and a force F is applied on it with an angle θ. If μ is the coefficient of static friction, the minimum force required to just move the body is

(a) $\mu mg\cos\theta$ (b) $\mu mg\tan\theta$
(c) mg (d) $\frac{\mu mg}{\cos\theta+\mu\sin\theta}$

5. A thin uniform rod is rotating about an axis passing through its centre and perpendicular to its length, moment of inertia is I_0. Moment of inertia of rod about an axis through one end and perpendicular to the rod will be

(a) $I_0/2$ (b) $3I_0$
(c) $5I_0$ (d) $4I_0$.

6. If a body circulates in a vertical circle, then

(a) total energy of body remains constant
(b) angular momentum remains constant
(c) angular velocity remains constant
(d) none of the above.

7. A mass m is at a distance x from one end of a uniform rod of length l and mass M. The gravitational force on the mass due to the rod is

(a) $\frac{GMm}{(x+l)^2}$ (b) $\frac{GMm}{l(l+x)}$
(c) $\frac{GMm}{x^2}$ (d) $\frac{GMm}{\left(\frac{l}{2}+x\right)^2}$

8. An earth satellite is moved from one stable circular orbit to another higher stable circular orbit. Which of the following quantities increase for the satellite as a result of the change?

(a) gravitational force
(b) gravitational potential energy
(c) angular velocity (d) linear orbital speed.

9. The potential inside a hollow metallic sphere of radius r having a charge q^+ on the surface is

(a) zero (b) $\frac{q}{4\pi\varepsilon_0}\cdot\frac{1}{r^2}$
(c) $\frac{q}{4\pi\varepsilon_0}\cdot\frac{1}{r}$ (d) $\frac{q}{\varepsilon_0}$.

10. The length of a wire is l_1 when tension is T_1 and l_2 when tension is T_2. The natural length of the wire is

(a) $\frac{l_1+l_2}{2}$ (b) $\sqrt{l_1 l_2}$
(c) $\frac{l_1T_2-l_2T_1}{T_2-T_1}$ (d) $\frac{l_2T_1-l_1T_2}{T_1+T_2}$.

11. Which extinguishes a fire more quickly?

(a) boiling water (b) hot water
(c) ice (d) cold water.

12. A capillary tube of radius r is placed in a liquid. If the angle of contact is θ, the radius of curvature R of the meniscus in the capillary is

(a) r (b) $r\sin\theta$
(c) $r/\cos\theta$ (d) $r\cos\theta$.

13. A liquid having area of free surface A has an orifice at a depth h with an area a, below the liquid surface, then the velocity v of flow through the orifice is

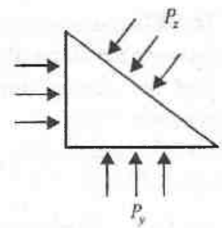
(a) $v=\sqrt{2gh}$ (b) $v=\sqrt{2gh}\sqrt{\frac{A^2}{A^2-a^2}}$

(c) $v=\sqrt{2gh}\sqrt{\frac{A}{A-a}}$ (d) $v=\sqrt{2gh}\sqrt{\frac{A^2-a^2}{A^2}}$

14. A sphere of mass M and radius R is falling in a viscous fluid. The terminal velocity attained by the falling object will be proportional to

(a) R^2 (b) R (c) $1/R$ (d) $1/R^2$.

15. A horizontal triangular element of the liquid is shown in figure. P_x, P_y and P_z represent the pressure on the element of the liquid. Then



(a) $P_x = P_y \neq P_z$
(b) $P_x = P_y = P_z$
(c) $P_x \neq P_y \neq P_z$
(d) $P_x^2 + P_y^2 + P_z^2 =$ constant.

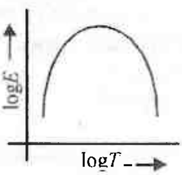
16. A pendulum clock goes 5 sec fast at 15°C and 10 sec slow at 30°C. At what temperature will it keep correct time?

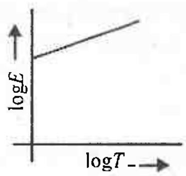
(a) 20°C (b) 18°C (c) 22°C (d) 25°C.

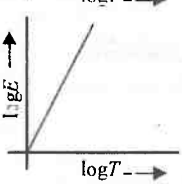
17. Consider the radiations emitted by the human body. Which of the following statements is true?

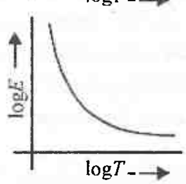
(a) radiations lie in ultraviolet region
(b) radiations lie in infrared region
(c) radiations are emitted during the day
(d) radiations are emitted during summer and absorbed during winter.

18. If the rate of emission of radiation by a body at temperature T (K) is E then the graph between $\log E$ and $\log T$ will be

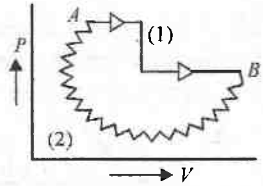
(a) 

(b) 

(c) 

(d) 

19. In the given P-V diagram the path (2) from A to B is zig-zag path, but (1) is simple path. Then



(a) $W_1 = W_2$
(b) $\Delta U_1 = \Delta U_2$
(c) $W_1 > W_2$
(d) both (b) and (c) are correct.

20. At a certain temperature, hydrogen molecules have rms velocity 2 km/sec. The rms velocity of oxygen molecules at same temperature is

(a) 2 km/sec (b) 8 km/sec
(c) 0.5 km/sec (d) 1 km/sec.

21. In an energy recycling process, X gram of steam at 100°C becomes water at 100°C which converts Y g of ice at 0°C into water at 100°C. The ratio of X/Y will be

(a) 1/3 (b) 2/3
(c) 3 (d) 2.

22. The value of C_V for 1 mole of polyatomic gas is (f = number of degrees of freedom)

(a) $\frac{fR}{2T}$ (b) $\frac{fR}{2}$

(c) $\frac{fRT}{2}$ (d) $2fRT$.

23. Two particles A and B of equal masses are suspended from two massless springs of spring constants k_1 and k_2 respectively. If the maximum velocities during oscillation are equal, the ratio of amplitudes of A and B is

(a) $\frac{k_2}{k_1}$ (b) $\sqrt{\frac{k_2}{k_1}}$

(c) $\frac{k_1}{k_2}$ (d) $\sqrt{\frac{k_1}{k_2}}$.

24. An air column closed at one end and open at other end resonates with a tuning fork when 45 and 99 cm of length. The wavelength of the sound in air column is

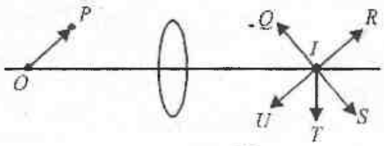
(a) 36 cm (b) 54 cm
(c) 108 cm (d) 180 cm.

25. The relation between frequency n of the string, if n_1, n_2, n_3 ... are the frequencies of segments of the stretched string is

(a) $n = n_1 + n_2 + n_3 + \ldots$ (b) $n=\sqrt{n_1 \times n_2 \times n_3 \times \ldots}$

(c) $n = n_1 \times n_2 \times n_3 \ldots$ (d) $\frac{1}{n}=\frac{1}{n_1}+\frac{1}{n_2}+\frac{1}{n_3}+\ldots$

26. A point object O moves from the principal axis of a converging lens in a direction OP. I, the image of O, will move initially in the direction



(a) IQ (b) IR
(c) IS (d) IU.

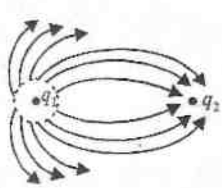
27. The critical angle for light going from medium X into medium Y is θ. The speed of light in medium X is v. The speed of light in medium Y is

(a) $v(1 - \cos\theta)$ (b) $\dfrac{v}{\cos\theta}$
(c) $v\cos\theta$ (d) $\dfrac{v}{\sin\theta}$.

28. In a Young's double slit experiment, $\lambda = 6000$ Å; $d = 6$ mm and $D = 2$ m. Find the position of the 2nd minima.
(a) 0.3 mm (b) 0.2 mm
(c) 1.5 mm (d) none of these.

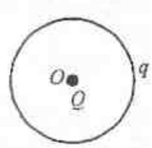
29. In an astronomical telescope, which one is not true?
(a) the objective has large aperture
(b) the objective has less focal length than the eyepiece
(c) when the length of tube is minimum, the eye is most strained
(d) the difference between the focal lengths of the two lenses is large.

30. The field lines of two point charges are shown in figure. The ratio of q_1/q_2 is



(a) 2
(b) 3
(c) 1
(d) none of these.

31. A point charge Q is placed at the centre of a circular wire of radius R having charge q. The force of electrostatic interaction between point charge and the wire is



(a) $\dfrac{qQ}{4\pi\varepsilon_0 R^2}$ (b) $\dfrac{q^2}{4\pi\varepsilon_0 R}$
(c) zero (d) $\dfrac{Q}{4\pi\varepsilon_0 R^2}$.

32. If V_0 is the potential at origin in an electric field $\vec{E} = E_x\hat{i} + E_y\hat{j}$, the potential at the point (x, y) is
(a) $V_0 - xE_x - yE_y$ (b) $V_0 + xE_x + yE_y$
(c) $xE_x + yE_y - V_0$
(d) $\sqrt{x^2+y^2}\left(\sqrt{E_x^2+E_y^2}\right) - V_0$.

33. A point charge Q is placed at almost just above the centre of the flat surface of hemisphere. The electric flux passing through flat surface of hemisphere is
(a) Q/ε_0 (b) zero
(c) $2Q/\varepsilon_0$ (d) $Q/2\varepsilon_0$.

34. When a dielectric medium of constant K is filled between the plates of a charged parallel plate condenser; then the energy stored becomes, as compared to its previous value
(a) K^{-2} times (b) K^2 times
(c) K^{-1} times (d) K times.

35. If σ_1, σ_2 and σ_3 are the conductances of three conductors, then their equivalent conductance when they are joined in series will be

(a) $\sigma_1 + \sigma_2 + \sigma_3$ (b) $\dfrac{(\sigma_1\sigma_2\sigma_3)}{\sigma_1+\sigma_2+\sigma_3}$
(c) $\dfrac{1}{\sigma_1}+\dfrac{1}{\upsilon_2}+\dfrac{1}{\sigma_3}$ (d) none of these.

36. A mains line has power 11 kW. The maximum number of 100 W bulbs which can be connected for full glow are
(a) 10 in series (b) 100 in parallel
(c) 110 in parallel (d) 60 in parallel or series.

37. In a thermocouple minimum current flows at
(a) neutral temperature (b) inversion temperature
(c) half of the neutral temperature
(d) 3/2 of the neutral temperature.

38. If a charged particle is describing a circle of radius r in a magnetic field with a time period T, then
(a) $T^2 \propto r^3$ (b) $T^2 \propto r$
(c) $T \propto r^2$ (d) $T \propto r^0$.

39. The S.I. unit of co-efficient of self inductance, the henry can be written as
(a) weber/ampere or volt-second/ampere
(b) joule/(ampere)^2 (c) ohm-second
(d) all of the above.

40. If $V = V_p \sin\left(\omega t + \dfrac{\pi}{3}\right)$ when will the voltage be

maximum for the first time?

(a) $T/6$ (b) $T/12$
(c) $T/3$ (d) none of these.

41. The needle of the dip circle at a place stays at 30°. The dipcircle is inclined at an angle of 30° with the magnetic meridian. The true dip at the place is

(a) $\tan^{-1}\sqrt{3}$ (b) $\tan^{-1}\frac{\sqrt{3}}{2}$
(c) $\tan^{-1}\frac{3}{2}$ (d) $\tan^{-1}\frac{1}{2}$.

42. Once a particle is moving in a circle, if there is no loss of energy due to friction, the particle continues to make a circular motion because of

(a) a torque applied by the centrifugal force
(b) a torque applied by the centripetal force
(c) conservation of angular momentum
(d) conservation of linear momentum.

43. If the relative permeability of a material is 0.9999 then its nature will be

(a) ferromagnetic (b) non-magnetic
(c) diamagnetic (d) paramagnetic.

44. Photoelectric effect was discovered by

(a) Einstein (b) Max Planck
(c) Guitel (d) Lenard.

45. The mass of a photon of wavelength λ is given by

(a) $\frac{hc}{\lambda}$ (b) $\frac{h}{\lambda c}$
(c) $\frac{h}{\lambda c^2}$ (d) none of these.

46. The angular momentum of electron in hydrogen atom is proportional to

(a) $\sqrt{r}$ (b) $1/r$
(c) r^2 (d) $1/\sqrt{r}$.

47. n alpha particles per second are emitted from N atoms of a radioactive element. The half-life of radioactive element is

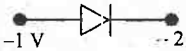
(a) $\frac{n}{N}$ sec (b) $\frac{0.693N}{n}$ sec
(c) $\frac{0.693n}{N}$ sec (d) $\frac{N}{n}$ sec .

48. In which case is the juction diode forward biased?

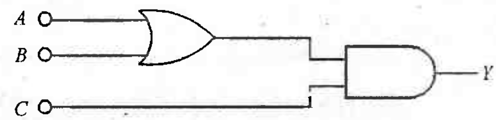
(a) 

(b) 

(c) 

(d) 

49. To get an output $Y = 1$ from circuit in figure the input must be



	A	B	C		A	B	C
(a)	0	1	0	(b)	1	0	0
(c)	1	0	1	(d)	1	1	0

50. An electric train in Japan runs with a speed of 1.5 Mach. It is approaching a station and blows a whistle of frequency 1000 Hz. The frequency of the whistle heard by a stationary observer on the platform is

(a) 1000 Hz (b) 1040 Hz
(c) 960 Hz (d) data insufficient.

ANSWERS

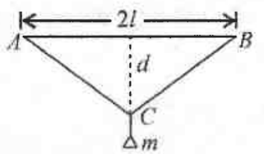
1. (b)	2. (a)	3. (d)	4. (d)	5. (d)
6. (a)	7. (b)	8. (b)	9. (c)	10. (c)
11. (a)	12. (c)	13. (a)	14. (a)	15. (b)
16. (a)	17. (b)	18. (b)	19. (d)	20. (c)
21. (a)	22. (b)	23. (b)	24. (c)	25. (d)
26. (c)	27. (d)	28. (a)	29. (b)	30. (a)
31. (c)	32. (a)	33. (d)	34. (c)	35. (d)
36. (c)	37. (b)	38. (d)	39. (d)	40. (b)
41. (d)	42. (c)	43. (c)	44. (d)	45. (b)
46. (a)	47. (b)	48. (d)	49. (c)	50. (a)

Contributed by : **Samir Chakraborty**, Burdwan (W.B.)

Thought Provoking Problems in PROPERTIES OF MATTER

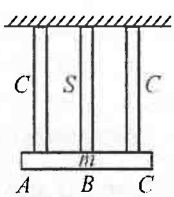
By : **Er. Sudhir Singh** *

1. A wire of radius r stretched without tension along a straight line is tightly fixed at A and B. A mass m is suspended from the mid point of the wire. Due to the weight of mass, the wire is pulled in the shape ACB. Find the depression 'd' in the wire. The length of the wire is $2l$ and its Young's modulus is Y.

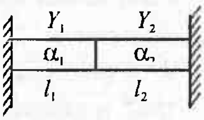


2. A sphere of mass 50 g is attached to one end of the steel wire, 0.315 mm diameter and one meter long. In order to form a conical pendulum, the other end is attached to a vertical shaft which is set rotating about its axis. Calculate the number of revolutions necessary to extend the wire by 1 mm. Young's modulus of elasticity of steel is 2×10^{12} dyne cm^{-2}.

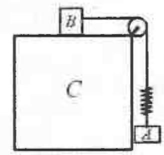
3. A homogenous block with a mass m hungs on three vertical wires of equal length arranged symmetrically as shown in figure. Find tensions of wires. One wire is of steel and the other two are of copper. All the wires have same area of cross section. Consider the modulus of elasticity of steel to be double than that of copper.



4. Two rods made of different materials are placed between massive walls. The cross section of rod is A and their respective lengths are l_1 and l_2. The rods are heated by t degree. Find the force with which rods act on each other if their coefficient of linear thermal expansion are α_1 and α_2 and moduli of elasticity of their materials are Y_1 and Y_2.



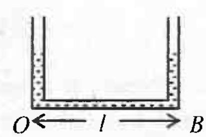
5. Two blocks A and B are connected to each other by a string and a spring, the string passes over a frictioness pulley as shown in figure. Block B slides over the horizontal top surface of a stationary block C and block A slides along the vertical side of C, both with same uniform speed. The coefficient of friction between the surface of block is 0.2. Force constant of the spring is 1960 N/m. If the mass of block A is 2 kg, calculate the mass of block B and energy stored in spring.



6. A solid sphere of radius R made of a material of bulk modulus K is surrounded by a liquid in a cylindrical container. A massless piston of area A floats on the surface of the liquid. When a mass M is placed on the piston to compress the liquid, what is fractional change in the radius of the sphere?

7. A vertical U tube of uniform inner cross-section contains mercury in both of its arm. A glycerine (density 1.3 g/cm^3) column of length 10 cm is introduced into one of the arm. Oil of density 0.8 g/cm^3 is poured in the other arm until the upper surface of the oil and glycerine are in the same horizontal level. Find the length of oil column. Density of mercury is 13.6 g/cm^3.

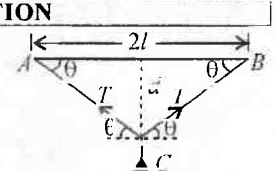
8. The monometer shown in figure contains a liquid of density ρ Find the difference in levels when the manometer rotates at a constant angular velocity ω about one of its vertical limbs.



SOLUTION

1. $2T\sin\theta = mg$

$$T = \frac{mg}{2\sin\theta} \quad ...(i)$$



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$\sin\theta = \dfrac{d}{\sqrt{d^2+l^2}}$ Since $d << l$ $\therefore d^2 + l^2 \approx l^2$

$\therefore \sin\theta = \dfrac{d}{l}$; $\therefore$ From (i) we get $T = \dfrac{mgl}{2d}$

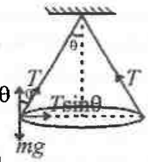
$$\text{Stress} = \frac{T}{A} = \frac{mgl}{2dA} = \frac{mgl}{2d\pi r^2}$$

$$\text{Strain} = \frac{\Delta l}{l} = \frac{\sqrt{d^2+l^2}-l}{l} = \left(1+\frac{d^2}{l^2}\right)^{1/2} - 1 \approx \frac{d^2}{2l^2}$$

or Young's modulus $Y = \dfrac{\text{stress}}{\text{strain}}$

$$Y = \frac{mgl}{2d\pi r^2}\times\frac{2l^2}{d^2}; \quad Y = \frac{mgl^3}{\pi r^2 d^3} \quad \text{or } d = \left(\frac{mgl^3}{\pi r^2 Y}\right)^{1/3}$$

2. $Y = \dfrac{\text{stress}}{\text{strain}} = \dfrac{T/A}{\Delta l/l}$



$\therefore T = \dfrac{Y\pi r^2 \Delta l}{l} = 1.559\times 10^6$ dyne

$T\cos\theta = mg \Rightarrow \cos\theta = \dfrac{mg}{T} = 0.0314$

$\sin\theta = \sqrt{1-\cos^2\theta} \approx 1$

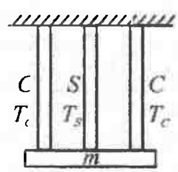
$T\sin\theta = \dfrac{mv^2}{r}$; $\quad v = \sqrt{\dfrac{rT\sin\theta}{m}} = 22$ cm/sec

$\text{Frequency} = \dfrac{1}{\text{Time period}} = \dfrac{1}{2\pi r/v} = 222$ rev/sec

3. $mg = 2T_C + T_S$ ...(i)

Since elongation of all wires are same

$\therefore dl = \dfrac{T_C/A}{Y_C/l} = \dfrac{T_S/A}{Y_S/l}$



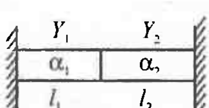
$\dfrac{T_C}{Y_C} = \dfrac{T_S}{Y_S}$: $Y_S = 2Y_C$ (Given)

$\therefore T_S = 2T_C$

From (i), we get

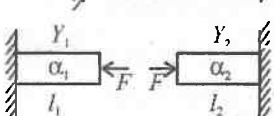
$$T_C = \frac{mg}{4} \text{ and } T_S = \frac{mg}{2}$$

4. Expansion of one wire due to temperature is balance by contraction of the compresed wire.



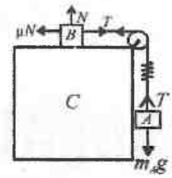
$dl_1 = \dfrac{Fl_1}{Y_1 A}$; $\quad dl_2 = \dfrac{Fl_2}{Y_2 A}$

$dl_1 + dl_2 = l_1\alpha_1 t + l_2\alpha_2 t$



$$\frac{Fl_1}{Y_1 A} + \frac{Fl_2}{Y_2 A} = (l_1\alpha_1 + l_2\alpha_2)t \quad F = \frac{(l_1\alpha_1 + l_2\alpha_2)tA}{\left\{\dfrac{l_1}{Y_1}+\dfrac{l_2}{Y_2}\right\}}$$

5. Since blocks moves with uniform velocity,



$\therefore$ accleration = 0 for block B

$T = \mu N$; $T = \mu m_B g$ ...(i)

No friction force will act on block A because normal reaction is not acting on this block.

$\therefore m_A g = T$ ...(ii)

From (i) and (ii), we get, $m_B = 10$ kg.

For spring $T = kl$ (l is stretching) $l = 10^{-2}$ m (only magnitude)

$\therefore$ Energy stored in the spring $= \dfrac{1}{2}kl^2$

$= 9.8 \times 10^{-2}$ J

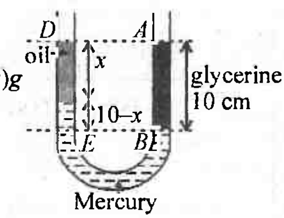
6. $K = \dfrac{Mg/A}{\Delta V/V}$ $\qquad \therefore \dfrac{\Delta V}{V} = \dfrac{Mg}{KA}$ ...(i)

$V = \dfrac{4}{3}\pi R^3 \Rightarrow \dfrac{\Delta V}{V} = \dfrac{3\Delta R}{R}$ ...(ii)

From (i) and (ii), we get, $\dfrac{\Delta R}{R} = \dfrac{Mg}{3KA}$

7. Pressure at

E = Pressure at B



$P_0 + \rho_O g x + \rho_{Hg}(10 - x)g$

$= P_0 + \rho_g g \times 10$ ...(i)

P_0 = atmospheric pressure

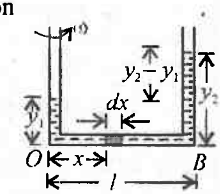
ρ_{Hg} = density of mercury

ρ_g = density of glycerine

ρ_O = density of oil

Subsituting values in equation (i) we get, $x = 9.6$ cm

8. Let A is area of cross section



$dm = \rho A dx$

Force on this dm

$dF = (dm)a$

$dF = \rho A dx\, \omega^2 x$ ($a = \omega^2 x$)

If dP is pressure on this

Then, we have

$(dP)A = (\rho A dx)\,\omega^2 x$, $\qquad dP = \rho\omega^2 x dx$

Pressure at O is $\rho g y_1$ and at B it is $\rho g y_2$

$$\therefore \int_{\rho g y_1}^{\rho g y_2} dP = \int_{x=0}^{x=l} \rho\omega^2 x\, dx \quad \text{we get, } y_2 - y_1 = \frac{\omega^2 l^2}{2g}$$